Rural the relationship between settlement pattern, water supply and land use in the khorasan district of Iran between the mid 1960s and the mid 1970s

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THE RELATIONSHIP BETWEEN RURAL SETTLEMENT PATTERN, WATER SUPPLY AND LAND USE IN THE KHORASAN DISTRICT OF IRAN BETWEEN THE MID 1960s AND THE MID 1970s

By

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DECLARATION

The material presented in this thesis has not been submitted either wholly or in part for a degree in this or any other university and is the original work of the author, except wherever acknowledged by reference or citation.

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DR A TRILSBACH

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ABSTRACT

This thesis examines the relationship between settlement patterns, water supply and land use in the Khorasan Province of Iran. In particular, the work concentrates on the period between 1966 and 1976 as most of the original material has been derived from the censuses of those years and also from the associated village gazetteers. Considerable time has been expended translating the raw data into complex settlement maps and these form a key link throughout the text.

The thesis begins by considering traditional settlement location theories and introduces some discussion as to their appropriateness for Iran. After some methodological considerations, the main body of the work begins in Chapter 3 with some discussion of the impact of physical factors on settlement location. This is followed by two key chapters which take the physical theme further with a detailed consideration of the relationship between settlement locations and the dynamics of water supply. Chapter 6 returns to the theme of settlement patterns with further consideration of spatial arrangement and settlement densities. The next three chapters examine the human aspects of settlement dynamics more fully with discussion of the impacts of land reform, agricultural land use and population trends respectively. The final chapter concludes the thesis and tries to reconsider the validity of some of the theoretical comments of Chapter 1.

The general conclusion demonstrates that since the 1960s there has been a movement towards some degree of potential settlement order, and a number of explanations for this are put forward.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 : SETTLEMENT THEORIES

INTRODUCTION

The study of settlements has been an important theme in human geography although approaches to this study have varied considerably. Various definitions of settlement geography have been argued. Singh (1961) commented that the geography of rural settlements deals with the way in which land is occupied and how settlements interact. Cohn (1972) suggested that rural settlements can be analysed on the basis of two historical sequences - the study of origin and evolution, and the functional relationships (see also James and Jones, 1959). Stone (1965) stated that the geography of rural settlements can be related to the primary occupation of the inhabitants, although in a later paper (1971) there was a suggestion that important note should be taken of settling and abandoning processes and their associated socio-economic consequences. In contrast, Jordan (1966) remarked that the rural settlement geography is essentially the study of cultural landscape. More radically, McMaster (1968) suggested that the subject is not part of population or human geography but it is an independent discipline focussing on settling processes and relationships between society and settlements. Doxialis (1970) emphasised this point in suggesting that there is a case, as well as a need, for developing a branch of science to deal specifically with settlement studies.

Having introduced briefly some of the approaches to settlement studies it is helpful to refer more specifically to some of the important models and theories which have investigated aspects of type, pattern and historical development. Well known theoretical models such as Central Place Theory and the Rank Size Rule are examined in detail in the last section. Before that an attempt is made to analyse the adequacy of other models, with particular reference to studies in India, which is more similar to Iran than other well-analysed regions. Other comments also refer to authors who have tried specifically to relate settlement patterns in Iran to theoretical order.

SETTLEMENT TYPES AND PATTERNS

Rural settlements are an essential part of the cultural landscape. They display marked regional variations according to type as well as in the pattern of distribution. Many geographers have tried to examine these aspects of settlements in relation to various influences of physical, functional and cultural forces. In 1972 Shrivastava analyzed the distribution, type and spatial arrangement of rural settlements in the Upper Son basin of India, which is mostly settled by tribal groups. His work showed that different socio-cultural factors and traditions have resulted in different patterns and distributions although modified by the physical setting. In his paper on the "Impact of physical and social factors on settlement types in the Indian Thar", Pandey (1972) analyzed the physical and cultural factors which helped to explain nucleated and dispersed habitations in an arid environment. He concluded that water supply problems, sandy soil, undulating topography, large and massive expanses of sand-dunes, poor transport facilities and agricultural instability explained dispersed settlements in the area. Jaiswal (1972) studied settlement types in the eastern parts of Ganga-Yamura Doab, India, which ranged from compact villages to dispersed or scattered habitations. According to him the surface configuration, soils and many cultural factors played roles in determining the site and pattern of rural settlements. Similarly, Jain (1972) studied the eastern district of Vidarbha region in Maharashtra and analyzed the emergence of different cultural landscapes and patterns of rural settlement under the impact of several physical factors. In his paper "Human Settlements in the Western Central Himalayas" Kaushic (1972) noted that the types and patterns of Himalayan settlements are related to both the physical and socio-cultural processes and the predominantly governing factors of settlement ecology are the relief, soil and particularly climate and gradient of slope. In a comprehensive review of settlement types Beaujeu-Garnier & Chabot (1967) identified functional characteristics based on military, commercial, industrial, cultural, tourism and administrative roles as key explanations for settlement formation and development. Using the frequency of hamlets per unit area Singh (1969) attempted to classify rural settlement types in the Varanasi district of India and mapped out the 'hamleted', 'semi-compact' and 'compact' rural settlement areas to show the nature of dispersion and suggested that the nucleated patterns were a response to the needs of occupation and defence. Verma's (1972) paper discussed types and distributions of rural settlements in the Qudh region of India. The aúthor has briefly analyzed the morphology of the plain in relation to various physical factors, and noted the varying socio-economic and cultural factors in explaining the types of rural settlements. Taken as a whole, these studies demonstrate the complexity of settlement patterns and identify the wide range of underlying factors which can explain the patterns.

HISTORICAL DIMENSIONS

Various writers have attempted to show the historical development and processes of rural settlements. Martin and Steel (1954) divided the

Oxford region into five sequences of time-period; pre-historic, Roman, Anglo-Saxon, Medieval and 17th to 19th Century period and, on the basis of archaeological and other records, succeeded in tracing the evolution and development of rural settlements. Singh (1955) traced the evolution of rural settlement patterns and their characteristics in the Middle Ganges valley of India. He identified six chronological periods; pre-historic, Aryan, Buddhist, post-Buddhist, Muslim and modern. His study identified the role of socio-cultural factors in explaining different settlement patterns in each of the periods. A similar study has been conducted by Ahmad and Kureishy (1961) in west Pakistan who identified four chronological periods, pre history, proto-historic, historical, and British and post-partition, and Singh (1970) who studied the evolution of Rayput clan-settlements in part of the middle Ganga valley and identified five historic-cultural periods: ancient, pre-Rayput, early medieval, post-Rayput and present. With the help of place name evidence Mutton (1938) attempted to illustrate the various phases in the evolution and distribution of settlement in the Black Forest and Rhine area and Mitchell (1954) stated that the languages of place names gave clues to the early settlers and the distribution of languages, which in turn helped to identify historical settlement patterns. Kameron (1951), Jones (1960), Schram (1961) and Singh (1966) have also based their settlement studies in historical geography on place name evidence.

Hudson (1969) suggested a new historical interpretation of rural settlements with reference to studies of Iowa in the United States between 1870 and 1960. He saw settlement patterns emerging as a result of three processes akin to the ecological interpretations of social areas within cities. Firstly he identified a 'colonization' phase where migration occupied relatively-virgin land. Density is then increased through 'spread', often marked by short distance dispersal, and finally 'competition' results in greater regularity of spacing as farmers seek areas of land for viable economic survival. Using mathematical formulae he shows that increasing regularity of spacing can be expected through time and he relates this to studies of geometric patterns.

quoted have contributed little to an understanding of order and logical spatial arrangements. This gap has been filled for more than half a century by a number of theoretical models which allow more systematic analyses of shape and pattern. Although there are many variants, the emphasis in this chapter is based on Central Place Theory and the Rank Size Rule. After some initial comments, they are discussed with specific reference to Iran.

CENTRAL PLACE THEORY

Central Place Theory was a pioneering approach to explaining settlement pattern through a pre-determined hierarchy. In particular, it is associated with the work of Walter Christaller in Southern Germany (1933). it is based on a number of assumptions such as an agricultural area which has a uniform physical and socio-economic landscape. Relying on such assumptions one would expect a uniform pattern of settlements and a geometrically based concentration of population; the population would be spread equally among the villages and towns which are regularly patterned and spaced at regular intervals (Figures 1.1 and 1.2). However, in reality such uniform characteristics do not exist due to many physical, cultural and socio-economic variables.

A principal feature of Central Place Theory is the form of pattern where smaller population centres or villages have access to equi-distant larger central ones for obtaining higher order goods or services. In other words, there is a nested hierarchy of centres with higher order centres fulfilling the needs of lower order ones. In this model, although a circle is an ideal shape for defining 'spheres' of influence (Figure 1.3 and 1.4) it is replaced by the hexagon to avoid overlapping areas (Figure 1.5).

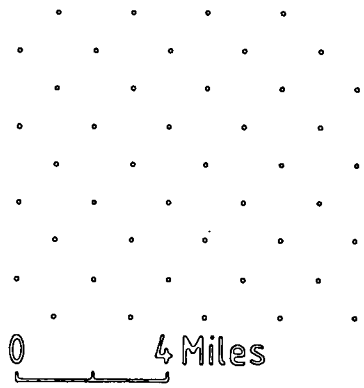


Figure 1.1

Theoretical even spacing of settlements: triangle network.

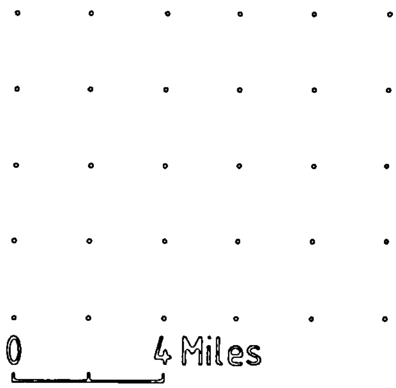


Figure 1.2

Theoretical even spacing of settlements: chequered network.

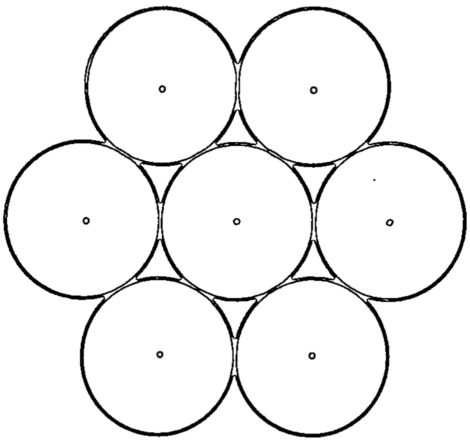


Figure 1.3

Maximum covering of spheres without overlap.

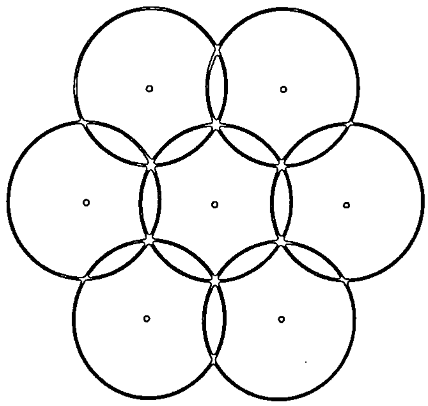


Figure 1.4

Maximum (total) coverage with overlapping spheres.

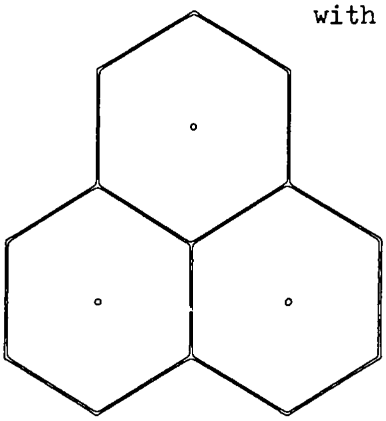


Figure 1.5

Hexagon coverage derived from overlapping spheres.

Table 1·1 The Urban Hierarchy in South-west Germany

Settlement form	Distance apart (km)	Average population	Size of Tributary (km^2)	Population of Tributary area
Market hamlet	7	800	45	2,700
Township centre	12	1,500	135	8,100
County seat	21	3,500	400	24,000
District City	36	9,000	1,200	75,000
Small State capital	62	27,000	2,600	225,000
Provincial head capital	108	90,000	10,800	625,000
Regional Capital city	186	300,000	32,400	2,025,000

Source: T.H. Johnson. Urban Geography, an introductory analysis 1972, p.101.

As stated, the hexagonal arrangement of settlement location was first introduced by the German geographer Walter Christaller in 1933. In its simplest terms Christaller's scheme proposed that towns with the lowest level of specialization would be spaced regularly and surrounded by hexagonally shaped hinterlands. For six of these towns there would be a larger, more specialized city which, in turn, would be situated at an equal distance from other cities with the same level of specialization as itself. Such a city would also have a larger hexagonal service area for its own specialized services. Even more specialized settlements would also have their own hinterlands and be located at an equal distance from each other, creating a nested hierarchy. Christaller classified the service centres, towns and cities by size, he calculated theoretically their distance apart and the size and population of their hinterlands. On his sample study he calculated that the smallest centres were likely to be located 7 kms apart. Centres of the next order of specialization were thought to serve three times the area and three times the population. By his calculations he predicted that the next tier of settlements would be located 12 kms apart. Similarly the area of the hinterlands of centres at the next level of specialization would again be three times larger (Table 1.1 and Figure 1.6). This kind of arrangement has been called a K = 3 hierarchy in which the number of centres at successively less specialized levels in the urban hierarchy follow a geometric progression (1.3.9.27....). A hierarchy with these features exhibits what Christaller has called the "marketing principle" in which the supply of goods from central places is as near as possible to the places supplied. A higher order central place will serve (apart from the central place itself) either two of its lower-order neighbours, or alternatively one-third of each of its six nearest neighbours.

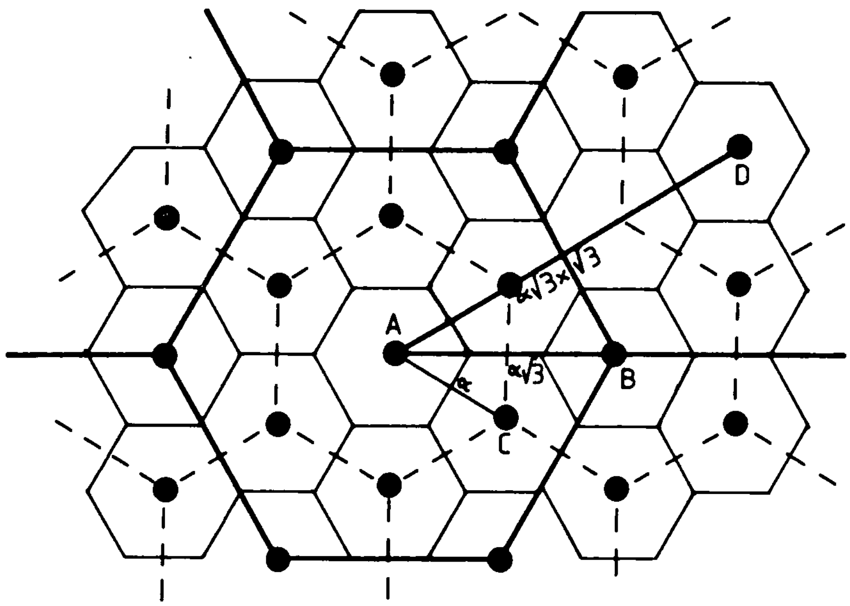


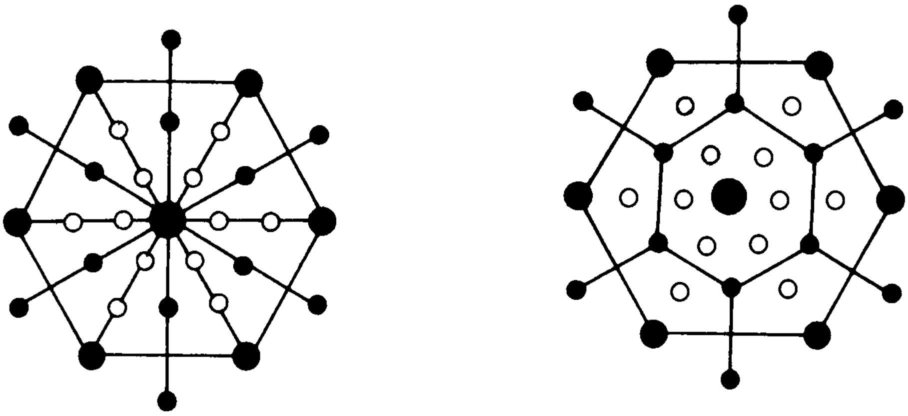
Figure 1.6

Sample K3 network. Each level in the hierarchy is characterised by settlements spaced evenly apart on the geometric progression of 1.3.9.27....

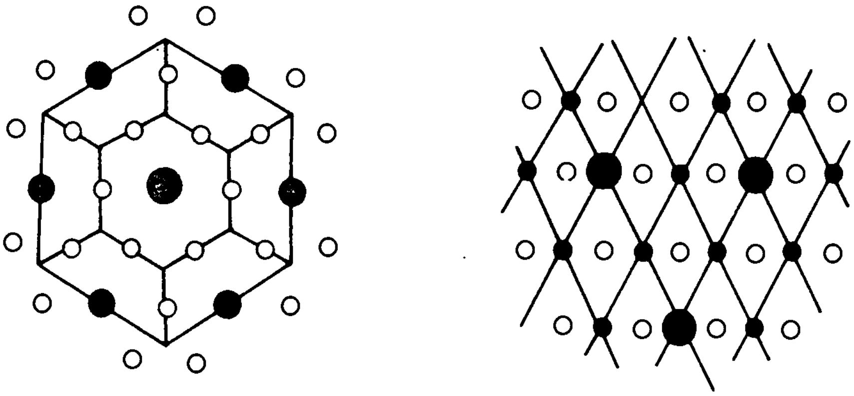
By a slight distortion of the geometric pattern, Christaller also suggested that where the cost of the traffic network is important a K = 4 hierarchy may be expected where a higher-order place serves (apart from the central place itself) three adjacent lower-order places. It may be either three of its nearest neighbours or by sharing them with another central place of the same order (Figure 1.7). The third case of hierarchy which Christaller has discussed is a K = 7 hierarchy where administrative control is decisive. In this case each lower-order centre falls clearly within the trade area of a single central place (Figure 1.7).

All the figures employed by Christaller in his theory are based on conditions in W. Germany, but he thought that it could be generalized to Western Europe in general. Christaller's plan of the south German villages shows that their locations approximated to his theory in terms of the size of the central villages, their higher order of centrality and their approximate distances apart.

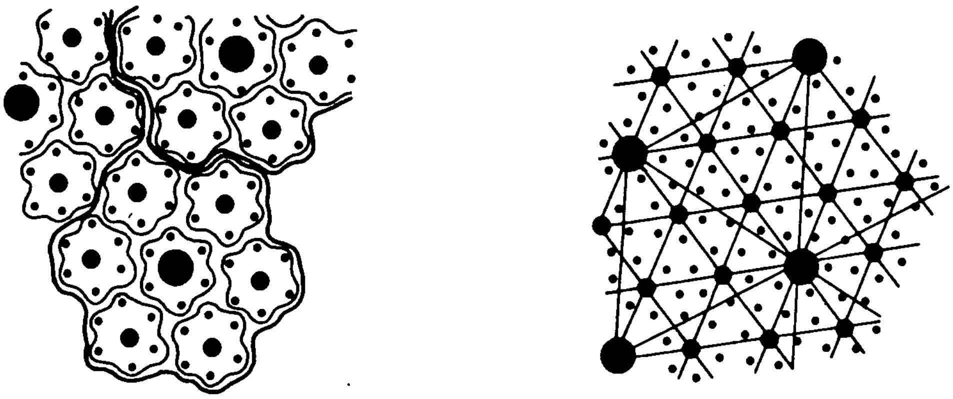
Christaller's ideas have been severely tested and criticised since he first suggested his theory. Brush (1953) selected an area of southern Wisconsin for an analysis of the hierarchy of central places. He categorized the settlements into three strata - hamlets, villages and towns successively found as 61, 31 and 8 per cent of the total number of settlements. Then Brush and Bracey (1955) proceeded to compare rural places in south western Wisconsin and southern England. He found that despite the strong differences in population density, economic function, and social and political history between the two areas, both showed two identical tiers of central places; a tier of higher order centres spaced



K3 - Marketing principle



K4 - Transport principle



K7 - Administration principle

Figure 1.7
The three controlling principles identified by Christaller.
After Carter, H. (1977).

at eight to ten mile intervals. Bracey (1962) in the study of central villages in Somerset, England recognized first-order, second-order and third-order villages but based his classification on a continuum (number of shops) with breaks at five, ten and twenty shops. Singh (1955), in his study of spatial aspects of central place in the Middle Ganga valley presented an account of general economic and cultural patterns and rural-urban linkage and showed the hierarchical orders of rural huts, market villages, 'rurban' centres and local towns. He also compared his pattern with the studies of Wisconsin and southern England which had been earlier studied by Brush and Bracey. Bhattachrya (1970) took castes and their groupings for his classification of settlements where he divided the settlements of Darjeeling into different hierarchical orders. Hira Lal (1972) in his study entitled "Gradient of Urban influence on the rural settlement concentration with special reference to Bareilly" attempted firstly to classify the villages situated within the rural-urban fringe of Bareilly into various concentric rings dependent upon their distances from the city. Secondly, the spatial pattern of various urban indicators such as the density of houses and population proportion of built up area to total area, percentage of non-farm population to the total population, the nature of settlement dispersion and decennial growth of the population, and were studied in order to trace the gradient in relation to distance from the city. Deshmukh (1972) provided an outline of functions of rural settlements of the Buldana district of Maharastra state. He found that higher non-agricultural functions, services and professions were poorly developed in general and were available at a few advantageous locations. He also conducted some analyses of the threshold of some functions in relation to the size of the settlements (Johnson, 1972; Haggett, 1975)

The above studies and many others (Johnson, 1972; Haggett, 1975; Marshall, 1977) have gone some way to indicate the complexities and lack of conformity of Central Place Theory. In simple terms, the theory has many weaknesses, not least the difficulty of marrying geometric theory with a varied physical landscape and the failure for people to act in the way that Christaller suggested. Due to a lack of perfect information, cultural influences, transport difficulties and so on, people do not necessarily demand services from their nearest place, which adds yet another twist to theoretical arrangement.

However, if Central Place Theory breaks down in detail, it does enable one to understand logic and order in settlement patterns and as a 'general' principle it may have considerable merit. To pursue this further it is perhaps useful to discuss a similar theory to Christaller's, that of August Lösch (1954).

Losch's theory uses the same basic hexagonal unit as Christaller but he evolved a markedly different hierarchy. While Christaller's hierarchy consists of several fixed tiers in which, according to the theory, all places in a particular tier have the same size and function and all higher-order places perform all the functions of smaller central places, the Losch hierarchy consists of a nearly continuous sequence of centres rather than distinct tiers. So settlements of the same size need not have the same function. Whereas Christaller's theory is more concerned with market centres as centres of shopping and basic services, Losch deals with areas of economic production and the more advanced services. While Christaller takes the populated areas of high service capacity as focal places to which smaller areas are dependent, Losch offers an opposite theory. He attempts to draw a general pattern based on a combination of several centres. In other words Christaller believes in a hierarchy formed of units such as retail centres, whereas the theory presented by Losch is based on a varied system of economic activities. The contrast is therefore between the basic marketing patterns suggested by Christaller as a basic element of his theory and specialized market activities presented by Losch.

Following Christaller and Losch other geographers, economists and planners have tried to develop their central place theories, Amongst them, mention could be made of Beckmann (1958) who tried to summarise the hierarchical system and prepare mathematical formulae. Range of a good (distance over which people are prepared to travel to obtain a particular service) and the threshold (the minimum amount of purchasing power necessary to support the supply of a particular type of goods or service from a central place) which are the two factors controlling the distribution of central places were studied by Garrison and Berry (1958). As a result of the operation of these two factors it is logical to expect a hierarchy of central places. More specialized services require a larger threshold, but also have a more extensive range. Hence they are found in those larger settlements which provide enough purchasers to support them, drawn both from their own populations and from that of their extensive zones of influence.

CENTRAL PLACES IN IRAN

It has been mentioned that Central Place Theory is based on the fact that the settlements form a hierarchical system. This is a mutual relationship and may be summarized as noting that (a) various city functions provide special patterns of service around them which are limited and closed and (b) that people benefiting from these services intend to use those nearest to them. It is of merit here to discuss the appropriateness of these ideas for settlement patterns in Iran.

In his book a "City and village in Iran" Paul English (1966) points out that cities and villages are two complementary centres of economy and enjoy a mutual relationship. In particular, English deals with the population centres of the Kerman region and draws the following hierarchy : large cities (as centres of a region), secondary regional centres, centres of agriculture and handicrafts, and smaller villages. How accurate and relevant Christaller's or English's hierarchical classifications are can be a matter of controversy. It is very difficult to find a logical geometric interpretation to the relationship of Iranian villages to geographical elements and to the region as a whole. A related question is whether their existence is necessary for the development of both urbanization and the dispersal of population. In general, the theory in relation to Iran projects some fundamental issues of great significance which may be outlined by the following:

i) Christaller's theory is based on the assumption that the development of population centres is due to their role in providing services. Therefore it suggests that the population in any given area should be dispersed equally regardless of their topographic and geographical elements, because the reason for their existence is due to the system of services. This idea, although maybe relevant to southern Germany or western Europe is quite different in Iran. Here one can see the existence of a remarkable physiographic and geographical diversity

(Chapter 3). Many forms of landscape such as flat deserts, high mountain ranges, valleys, coastal plains and closed basins are found lying in close juxtaposition to one another, each dictating a special pattern of settlement and form of population distribution. Also, contrary to Christaller's theoretical plan, many Iranian people do not look to the demand for services to explain the location of population centres, as cultural and economic values are different. More than anything else, however, the location of water resources dictate that many settlements cluster in several regions of Iran.

ii) Another important issue in connection with Christaller's theory is that his theory has emerged from the study of a particular area which has a markedly different culture and history than Iran. For example it has been argued that the feudal organization of agriculture in Christaller's study area was a stimulus to the development of a hierarchical system (Haggett, 1975), while the Iranian type of feudalism and administration was not suited to the formation of a hierarchical system but supported centralism. Thus as English suggested, the concentration of the absentee landlords in some larger towns resulted in the progress of those centres and caused the decline of smaller ones. This, together with the fact that the concern of government has been almost entirely with the larger urban centres, has resulted in many villages failing to develop many services and therefore their development was individualistic and unorganized at a regional level. As a result, the advantage of distance to nearer small market centres is ignored and many villagers prefer to travel a long distance to the large market towns where they can be provided with a wider range of goods, a better chance of bargaining and easier and better access to specialized people. The following statement by English provides a good example of the important role of a large town as a market and service centre in the Kerman region of Iran:

"... the city is the major marketplace for everything the villagers produce. On a given morning, peasants travel to the city to sell a small rug, a mat, a woven cap, stockings, a goat, or any other item in order to buy fundamental necessities such as salt, sugar, tea or cloth. If his daughter is to be wed or his social position demands that a celebration be held, the peasant asks his landlord or weaving contractor for any advance, and failing that will have resource to the moneylenders of the bazaar. And debt is a binding tie; many debtors live in villages, most creditors in the city. If a villager has broken the law or the army threatens to induct him, his last appeal will always be to the most powerful urbanite he or his family knows. If he wishes to buy a cup, a plate, a religious photograph or icon, a samovar, or rug, he will travel to Kerman, where the choice is great and he can hope to find a bargain. The majority of specialized artisans, craftsmen, service workers, and professional people live in Kerman."

iii) Another notable point relates to geographic and topographical elements and the scarcity of water. The economic pattern does not correspond to geological specifications. In other words, the pattern of economic activities and dispersal of population in rural areas of Iran bears little relevance to the sources of raw material which are often left unused. This is partly due to the lack of long-term development programmes and the dependence of rural areas on agriculture. This, of course, is a dynamic element and oil and gas exploitation has begun to distort this simple premise.

iv) Unlike the case suggested by Christaller's scheme, the Iranian population is often inordinately dispersed, and as can be seen from Figure 1.8 the population curve does not show a regular continuity and is broken in two sections. In addition to the great difference of population concentration in Tehran and larger provincial capitals the break is firstly in the area of the population centres with 450,000 to 350,000 or 250,000 to 100,000 and secondly in the area of 50,000 to 100,000 people.

v) Central Place Theory is based on the existing condition of an area and fails to foresee population developments. It is thus only concerned with dispersal in its static form.

Despite the above mentioned unfavourable points with regard to the application of Christaller's Central Place Theory to Iran, his theory can be used as a basis for a study of settlement patterns and for presenting further and more advanced and relevant regularised pictures of the Iranian population centres. The works done in this field in various parts of Iran, as for example in Kerman by English (1966), in Esfahan by the University of Tehran (1974) and by Costello in Kashan (1976) suggest that the villages in Iran are organized into some form of recognizable system. In the case of Kashan region for example, Costello writes that there is a close positive correlation found between village size, functional range of services and number of functional units, which confirms the application of some western theories of central place to the settlement systems.

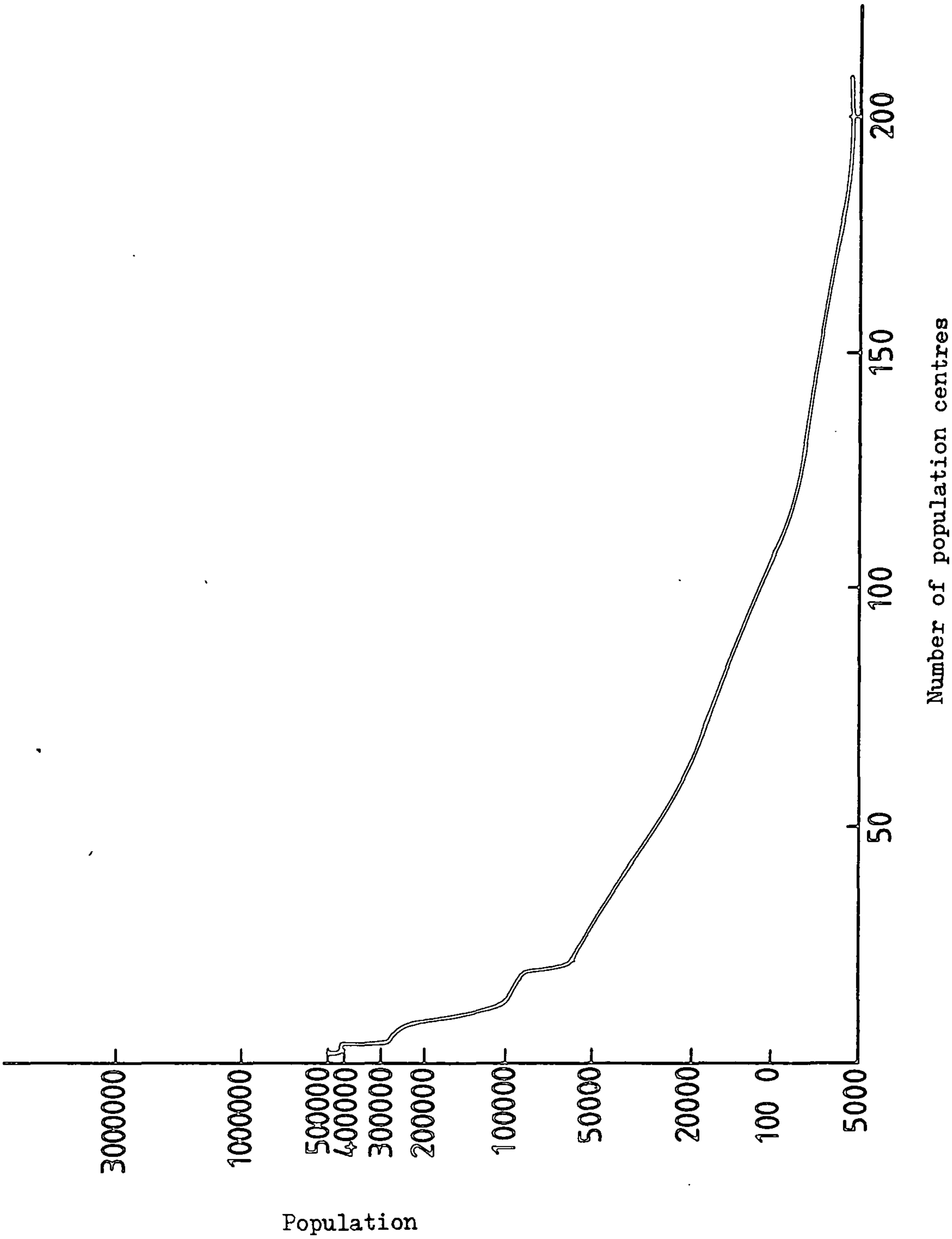


Figure 1.8 The distribution of population centres in Iran according to size (various sources).

Before examining this possibility for order further, it is worth considering one other important theoretical principle of order in settlement patterns - the Rank Size Rule.

RANK SIZE RULE

The Rank Size Rule is another interpretation of city size. The basic elements of the rule were originally put forward by the German geographer Felix Auerbach in 1913, but the best known study is that of Zipf (1941). In its simplest form, the rank size rule states that if one arranges all the cities of one country in descending order by population, then there will be a regular ratio between the position of each and its size in proportion to the largest city. Thus, the second city in the series is half the size of the first, the third is one third, the fourth is one quarter and so on. However, it should be noted that such a conception generally differs with that of Christaller's scheme. The Central Place Theory is basically concerned with producing a theoretical model of what reality was like in an ideal landscape. The Rank Size Rule, on the other hand, is simple an empirical observation, based on the study of actual population statistics and without any theoretical pretentions. Christaller's urban hierarchy would produce a stepped arrangement of urban size, while the Rank-Size rule implies a smooth progression of population size from rank to rank. The Rank Size Rule works best when a large area is being studied, while the urban hierarchy is most clearly seen in reality where a small non-manufacturing area is under study.

Berry (1961) studied the rank size distribution of towns with a population of 20,000 or more in 38 countries. Of all, only 13 had a regular rank-size distribution. His study suggests that the log-normal distribution exists where countries are larger than 'average', have a long history of urbanization, and are economically or politically complex. The rank-size distribution appears to fail in countries that are smaller than 'average', have a short history of urbanization, and have a simple economic and political structure. Thus unlike Zipf's concept of the Rank Size Rule, which is more related to industrial and highly urbanized countries such as the United States or Western Europe where rank size distributions do not exist, Jefferson's law of primacy is more applicable. This would apply in developing Middle Eastern countries such as Iran which have a relatively simple economy based on agriculture and are generally less urbanized. One of the problems of Zipf's Rank Size Rule with regard to Iran is that in Iran a great majority of settlements have a small population, whereas Berry's analysis, and other evidence upon which the Rank Size Rule is based has come from investigations of the size distribution of the larger cities and towns. In fact an investigation of small size settlements in Sri Lanka by Gunawardena (1964) suggests that the distribution of small settlements may display different trends to those suggested by the Rank Size Rule.

CONCLUSION

This chapter has introduced some of the various approaches to settlement studies that have been conducted, mainly with reference to Western Europe, North America and India. It has been demonstrated that 'order' has been sought through explanations of historical and cultural development, economic and social functions and through geometric logic. Clearly no idea is all-embracing, but the suggestions have facilitated some understanding of settlement patterns and hierarchies. One point which is stressed is the false assumption that ideas established in one region should apply to another, and comments have been made to show that the more arid environment of Iran has created a uniqueness which introduces new explanations of settlement order.

Following brief comments on the practical problems of this work (Chapter 2), the remainder of this thesis concentrates upon the Khorasan region of Eastern Iran (introduced in Chapter 3), where attempts are made to interpret the settlement landscape through a variety of phenomena, embracing water supply, land use, social mobility and so on. The concluding chapter of the thesis returns to the subject of this chapter and tries to see to what degree some of the existing settlement theories are applicable.

CHAPTER 2 : RESEARCH METHODOLOGY

THE RESEARCH AREA

The Ostan of Khorasan is situated in the north-eastern part of Iran between 30°.21' and 38°.17' N and 55°.28' and 61°.14 E. In the past its political boundaries enclosed a much larger area which included Sistan, parts of West Afghanistan, and a large area of present day Soviet Central Asia. Even within its present administrative boundaries it has an extensive land area of approximately 313,335 km² or nearly 20 per cent of the total land area of Iran. The Ostan is at present bounded on the north and east by the political frontiers of U.S.S.R. and Afghanistan, and to the west and south by the administrative Ostans of Mazandaran, Semnan, Esfahan, Yazd (to the west), and Kerman and Sistan-Baluchestan (to the South). Physically it is isolated from the rest of Iran by the geographical barrier of the Dasht-e-Kavir and Dasht-e-Lut deserts (see Figure 2.1).

The Selection of the Research Area : There were several reasons why Khorasan was selected for the area of this study. One important reason was the personal knowledge and familiarity with the geography of the region by the author through living, graduating and travelling in the area. A greater knowledge, however, was acquired through previous studies relating to the author's original choice of the study subject rural-urban migration and its negative effect on the provincial capital Mashhad, which, as will be explained later, had to be abandoned. The

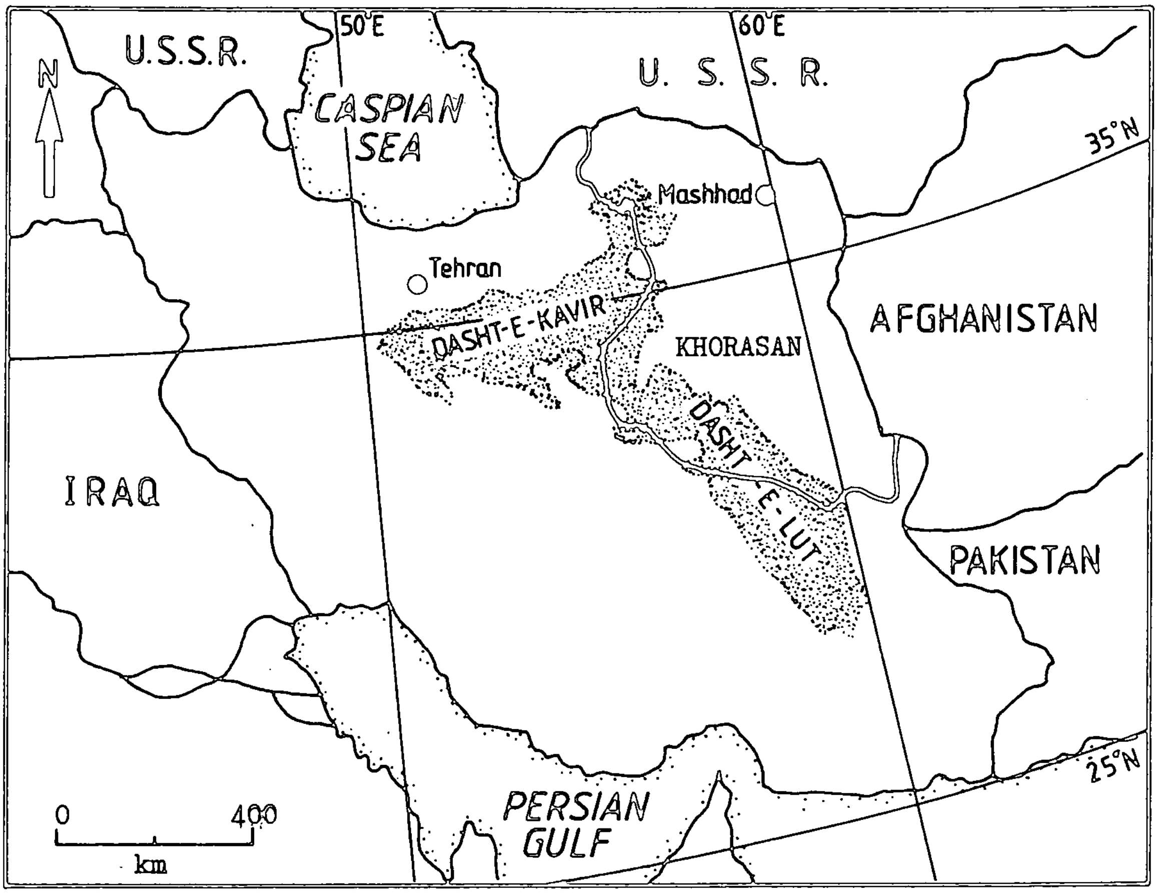


Figure 2.1 The geographical location of Khorasan in eastern Iran.

second major reason for the selection of the present area of study was the availability of a considerable amount of relevant raw data and published material at the University of Durham; these included Censuses on population and agriculture, annual statistical data, and various government reports, all of which were available at the Middle East Documentation Centre. A key publication in this work was the 1976 complete census and village gazetteer. This provided a considerable body of raw data which was used in various aspects of the present study, thus overcoming the problem of field work (see later). Another notable reason for the area's selection was its variety of landscapes which gives scope for considerable spatial analysis. The patterns of rural settlement in Khorasan show interesting features of conformity with the physical characteristics, such as water availability and land use, whilst challenging other theoretical aspects of distribution highlighted in Chapter 1.

Regional Divisions : One cannot easily determine the boundaries of the regional geographical divisions in Khorasan. This is partly due to elements of the physical environment, and partly due to the socio-economić characteristics, which are considerably varied and complex. Nevertheless, by considering topography, climatic variations and the patterns in which settlements are generally shaped, the present study will concentrate on three broad sub-regions which have been defined by the author to facilitate some general sub-regional comparisons. The regions are defined as follows: (Figure 2.2)

i) North Khorasan : Dominated by the valley of the Kashaf and the upper course of the Atrak. There is a predominant Mediterranean type of climate. It is also characterised by having a higher population density than the rest of Khorasan, a relatively higher level of socio-economic development, and a partially structured network of towns and villages which are comparatively larger, more closely spaced and have a predominantly linear pattern.

ii) Central Khorasan : Distinguished by irregular mountain ranges and a number of poorly drained basins which are dominated by a cold semi-arid type of climate. It is also characterised by a low population density, a generally low level of socio-economic development, a fairly sparse network of small towns and villages, which are of various sizes, are more widely spaced, and have a clustered pattern.

iii) Southern areas : Dominated by the Qaen-Birjand highlands, the area has a cold semi-arid type of climate in the highlands and a hot arid climate in lowland areas. This part of Khorasan is characterised by a very low population density, a low level of socio-economic development, small villages which are sometimes situated very close to one another, and a limited number of small towns acting as local centres.

Administratively, the Ostan is divided into 16 Shahrestans (1976 Census) namely : Mashhad, Quchan, Shirvan, Dargaz and Bojnurd in the north, Neyshabur, Sabzevar, Esfarayen, Kashmar, Torbat-e-Heydariyeh and Torbat-e-Jam in the centre, and Birjand, Tabas, Ferdows and Gonabad in the South (Figure 2.2). The Shahrestan is the basic unit of

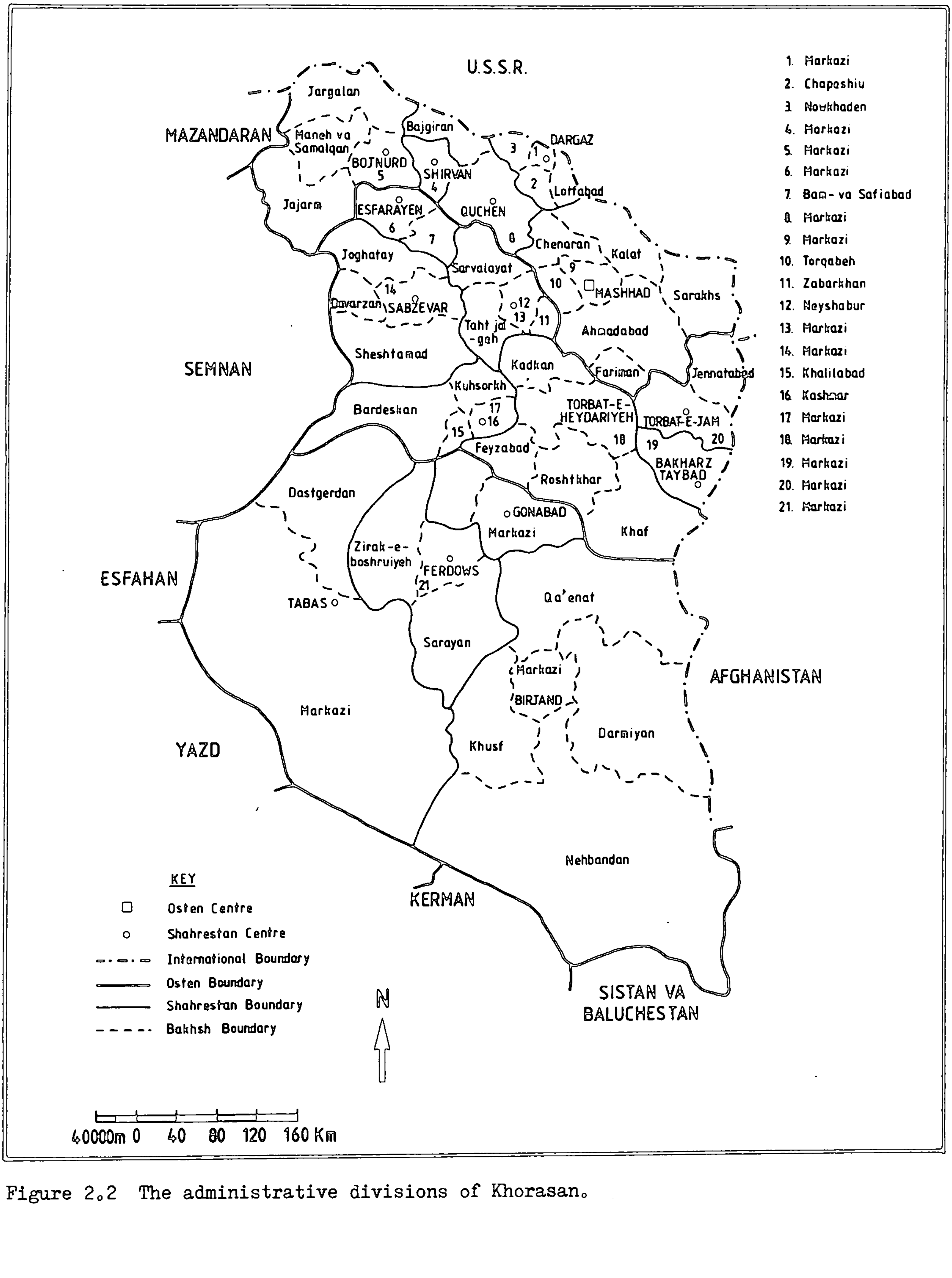


Figure 2.2 The administrative divisions of Khorasan.

administration and each is divided into several smaller units called 'Bakhsh' which again sub-divide into several village districts called 'Dehestan' (see Appendix 2.1).

SOURCES OF RAW DATA

As with other aspects of human geography the study of settlements relies considerably on the availability of statistical data. It may be appropriate here to refer to some of the main sources of data used in the present study.

i) Population data : the main sources of population statistics used in the present study are the Censuses of Population and Housing conducted in 1956, 1966, and 1976. These censuses provide statistics on various aspects of demographic, social, economic and dwelling characteristics for urban and rural areas, and for the province as a whole. However, while the first National Census of Iran in 1956 was published in census district volumes and also includes statistical information on villages, the National Censuses of Population and Housing conducted in 1966 and 1976 were published by Shahrestan volumes and did not include any data on individual villages. The statistical information obtained from these censuses in connection with individual villages were published in separate volumes of village gazetteers. Comments on data reliability from these censuses are made in the relevant chapters.

ii) Village gazetteers : The present study relies heavily on the village gazetteers. These sources are only concerned with villages (centres with a population of less than 5,000 inhabitants) and provide statistics and information on various aspects of the geography of each individual village. The information includes reference to topography, population, type of road, religion, education, health, communication facilities and the availability of socio-economic and public services in each village. The 1966 village gazetteer also included information on sources of water supply, to villages i.e. whether the principal source is from a qanat, well, river or other form of water source.

iii) Others : The other sources of information which are widely used in the present research work are the Censuses of Agriculture, Statistical year books, and numerous governmental statistics and reports published mainly by the Statistical Centre, Plan Organization and the Ministry of Agriculture and Water Supply. Furthermore, rainfall data was acquired for some of the principal stations of Khorasan. This was obtained with the helpful assistance of the Meteorological Office at Bracknell in Berkshire (England).

METHODOLOGY

In the present study, a great deal of work and analysis was done through mapping and classification of data. In the following paragraphs an attempt is made to outline some of the techniques employed in various aspects of these mapping and classification exercises.

Preparation of basic maps: The basic maps were prepared mainly to obtain the general pattern and size distribution of the settlements in the area and within its major regional divisions. To prepare the basic map, the 129 large scale sheets maps included in the 1976 village gazetteer were reduced several times. A mosaic was subsequently made and further reduced and transferred to A4 size sheets by photographic reduction. However, due to the limitations of scale only the locations of settled villages were transferred. Other information contained in the 1976 village gazetteer maps were ignored here, although included in other maps elsewhere in the thesis. Also, owing to the vastness of the area of study and its numerous number of settlements, it was found more appropriate tó present the basic map of provincial settlement patterns according to its three regional divisions. This provides adequate scope to assess the appearance of settlement patterns clearly by visual means.

Mapping and classification of data on settlement size : In the mapping of settlement size distribution the limitation of scale is a significant factor. Consequently the broad categories of village classifications are chosen (a) small size settlements, consisting of those villages with a population of less than 500 inhabitants (b) medium size settlements, that is those villages with a population of between 500 to 2000 and (c) large size settlements, having a population of 2000 to 5000 inhabitants. These broad classifications allow an impression of regional variation in size, pattern and economic structure to be made. They are useful in establishing the general hierarchical order and development status.

For a more detailed analysis of data, a wider range of settlement size classifications are also provided and tabulated. For this purpose the medium size category mentioned above is divided into two classes of 500 to 1000 and 1000 to 2000 inhabitants and because of the very small nature of the villages in the area the category of less than 500 has also been further divided into smaller classes of less than 100,100 to 250 and 250 to 500 inhabitants. The average percentage of each of the six classes mentioned above are calculated for each major and sub-divided areas and the variations are obtained. For the discussion of changing patterns and size, a similar classification of settlement size is also adapted for mapping and tabulating regional size variations on the basis of the 1966 village gazetteer.

Mapping of spacing and analysis of distance value : To obtain the average spacing among the villages a stratified random sampling method has been employed based on the 1976 village gazetteer data. A total of 124 villages were selected from all 16 shahrestans and 52 minor administrative divisions, in order to establish the presence of 'central' villages.

For this calculation of the study of spacing, the size and topographical condition of the villages are also taken into consideration. Of the total 124 villages selected as a centre for measuring the distance to other settlements, 44 were chosen from lowland and 42 from upland areas and the remaining 38 were chosen from the large villages regardless of their topographical location. In the predominantly upland areas the majority of selected villages were chosen from areas of relief and vice-versa for lowland areas. After the selection of villages the distance between them and their surrounding neighbouring villages (10 neighbouring surrounding villages were chosen for upland and lowland areas and 6 in the case of large villages) was measured and the average spacing value calculated for the major and minor divisions as well as for the province as a whole. The calculation facilitates an analysis of spacing value in uplands, lowlands and among the large villages. In a separate section the average number of villages per km^2 was also calculated for the province and its regional divisions.

Mapping and classification of data on abandoned villages : the 1976 village gazeteer also lists the abandoned villages. These concern the villages which in 1966 were reported to have a certain number of population, but at the time when the 1976 census was conducted had no inhabitants. To show the location and distribution pattern of 823 villages which had become abandoned during the 1966-1976 period a similar mapping process to the settlement pattern was employed. On the basis of these maps and the information provided in the 1966 and 1976 village gazetteers an attempt has been made to analyse some of the causes and search for some of the major responsible factors. For this purpose the abandoned villages were examined in relation to the type of water supply they had in 1966 and thus distinguished in the maps according to whether they used a source of qanat, well, or river water. For further analysis, the abandoned villages are also classified in relation to their physiographical conditions, their size of population in 1966 and their type of road and communication (see Appendix 2.2)

Mapping and classification data on water supply : the 1966 village gazetteer also provided data on the form of water supply to each village. The classification included qanat, deep and semi-deep well, river source, spring, or some other source. For the purpose of mapping the water supply distribution, all villages in the area are reviewed and classified according to three principle sources of water supply, qanat, deep and semi deep wells and river source. Accordingly, their locations are marked on three separate maps of water supply distribution for each of the North, Central and Southern sub-regions. Unfortunately, the village gazetteer of 1976 did not provide any data on water supply and thus it was impossible to show the changing pattern during the 1966-76 period. However, through comparison with the 1976 water supply investigation conducted by the Ministry of Water Supply the general trend and regional variation of the water supply during the mentioned period are discussed and analysed. Further, to show the degree of relationship between the villages and water supply, the variation in the number of these two variables in respect of 1976 data was tested using statistical techniques.

Mapping and classification of soils of Khorasan : to simplify the study of soils and land use distribution, three broad and more general classifications were chosen for the purpose of mapping

(a) soils with good to moderate potential land use

(b) soils with moderate to low potential agricultural land use

(c) soils with low to no potential agricultural land use.

These classifications were based on a map of grouping soils in relation to their general potential for agriculture which was published by Dewan and Famouri (1964) in association with the soils map of Iran. The above mentioned classification was chosen because it conformed with the classification made by the Ministry of Agriculture and Natural Resources. It also eases an analysis and comparison of the two maps of soil potential and that of settlement pattern.

<u>Classification of data on physiography</u> : physiographic character also is an important factor influencing the location and size of settlement. Thus in all important aspects of the study of settlements such as size, spacing or their abandonment, the physiographical situation of the villages was taken into consideration. To analyse the important role of topography in determining the location and pattern of settlements, the topographical map of the region was prepared on the basis of the 1,000,000 scale topographical map of Iran, and compared with the maps of settlement pattern.

<u>Climate</u> : In order to consider possible variations of precipitation on changes in settlement pattern, such as abandonment, temporal variations were assessed using a range of statistical and geographical techniques. These are explained in Chapter 3.

Statistical analysis of population data : on the basis of censuses the principal features of Khorasan's demographic development such as growth, distribution, change, structure and movement of population were analysed and standard deviations and the correlation between settlements and population were calculated. With the help of the censuses, and birth place and migration data, the number, and percentage of in-migration, out-migration and net migration for the years 1956 and 1966 were calculated and migration matrix tables presented. Also through analysis of migration and census data the contribution of net migration to population change in the cities of Khorasan for the decades of 1956-1966 and 1966-1976 were calculated and the regional variations shown. However, in the absence of reliable data on birth and death rates, the calculation has been based on the assumption of an equal rate of natural increase in urban and rural areas.

PROBLEMS OF FIELD WORK

The preparation of the present study faced many difficulties and limitations, mainly due to difficulties of obtaining up to date materials and data from Iran. Due to the Islamic Revolution and circumstances at the time, it was not possible to conduct field work in Iran. further problem was caused by the long-term political unrest and national strikes which resulted in a delay in processing and publishing many important data and materials, such as the publication of the complete census results for 1976 and the village gazetteer, both of which were essential for the present study. In order to overcome the problem of field work and the limitation of up to date data, the author was forced to place his study in a historical context. The period between the 1966 and 1976 was therefore chosen. Since a great deal of materials needed for this period, such as complete volumes of the 1966 census data, 1966 village gazetteer, Agricultural Census data, statistical year books and many governmental reports concerning the various aspect of the study were available in the Documentation Centre Library at Durham, the complete publication of the census data of 1976 and village gazetteer was later added to the collection which finally provided sufficient material for the data analyses and mapping procedures described. The choice of area of the study area with its considerable physical, and socio-economic diversity also helped in overcoming the problem of not being able to conduct field work in Iran, as it facilitated a sampling of data on geographic themes and in some detail.

Following an introduction to the geographical characteristics of Khorasan, the remainder of this thesis will concentrate on the settlement themes described.

CHAPTER 3 : KHORASAN AND ITS PHYSICAL SETTING

TOPOGRAPHY

The Khorasan Region can be divided into three distinct topographical sub-divisions (Figure 3.1); (i) Northern Khorasan, dominated by the Atrak-Kashaf valley (ii) Central areas, dominated by scattered relief and a number of irregular basins and (iii) Southern areas of Khorasan, which can be further divided into the eastern highlands of Qaen and Birjand, and the western flat desert areas. General topographical conditions of these main divisions are now discussed, together with their special effects on pattern, size and the spacing of settlements. The study is mainly based on the topographical map of the region (Figure 3.1) and the figures provided of settlement distribution (Figures 3.2, 3.3 and 3.4), spacing (See Chapter 6) and information derived from the 1976 village gazetteer of Khorasan concerning the topographical status of the villages (Table 3.1).

Northern division : The main topographical features of this part of Khorasan are two almost parallel ranges of mountains which run in a NW/SE direction. Although these mountains are much lower than Iran's most developed ranges of the Alburz and Zagross mountains, their peaks are sufficiently high (reaching more than 3,000 metres above sea level) to be permanently covered by winter snow. In spring they provide water to the Atrak-Kashaf valley formed in between. The valley is corridor-like, approximately 600 km in length and about 40 to 60 km wide. The western half of the valley, narrowly situated between Kuh-e-Cululdagh and Allah Akbar in the north and Kuh-e-Aladagh and Shah-Jahan in the south, is the bed of Atrak. Here, lie some of the

Table 3.1 Number and Average size of upland and lowland villages by regions

Regional divisions	Upland Area			Lowland Area		
	Number of villages	Total Population	Average size of villages	Number of villages	Total population	Average size of villages
Mashhad	463	125588	271.2	852	225813	265
Quchan	250	86443	345.8	154	70500	457.8
Shirvan	57	20820	365.3	56	20827	371.9
Dargaz	45	8797	195.5	114	29148	255.7
Bojnurd	329	99613	302.8	253	80903	319.8
Total North	1144	341261	298.3	1429	427191	298.9
Neyshabur	168	65227	388.3	512	126448	247
Sabzevar	215	65877	306.4	267	116865	437.7
Torbat-e-Jam	105	21314	195.5	202	61191	303
Torbat-e-Heydariyeh	152	52617	346.2	419	161316	385
Bakhezr	35	1693717	483.9	192	37410	194.8
Esfarayen	73	26503	285	109	35757	328
Kashmar	93	27797	298.9	170	87686	515.8
Total Central	845	276272	326.9	1871	626673	324.9
Birjand	1464	135637	92.6	535	83304	155.7
Gonabad	122	14524	119	108	39955	370
Ferdows	104	13515	129.9	129	26827	208
Tabas	112	18772	167.6	153	5873	38.4
Total South	1802	182448	101.2	925	155959	168.6
Khorasan	3791	799981	211	4225	1209823	286.3

Source : Village Gazetteer of Khorasan Province (1976)

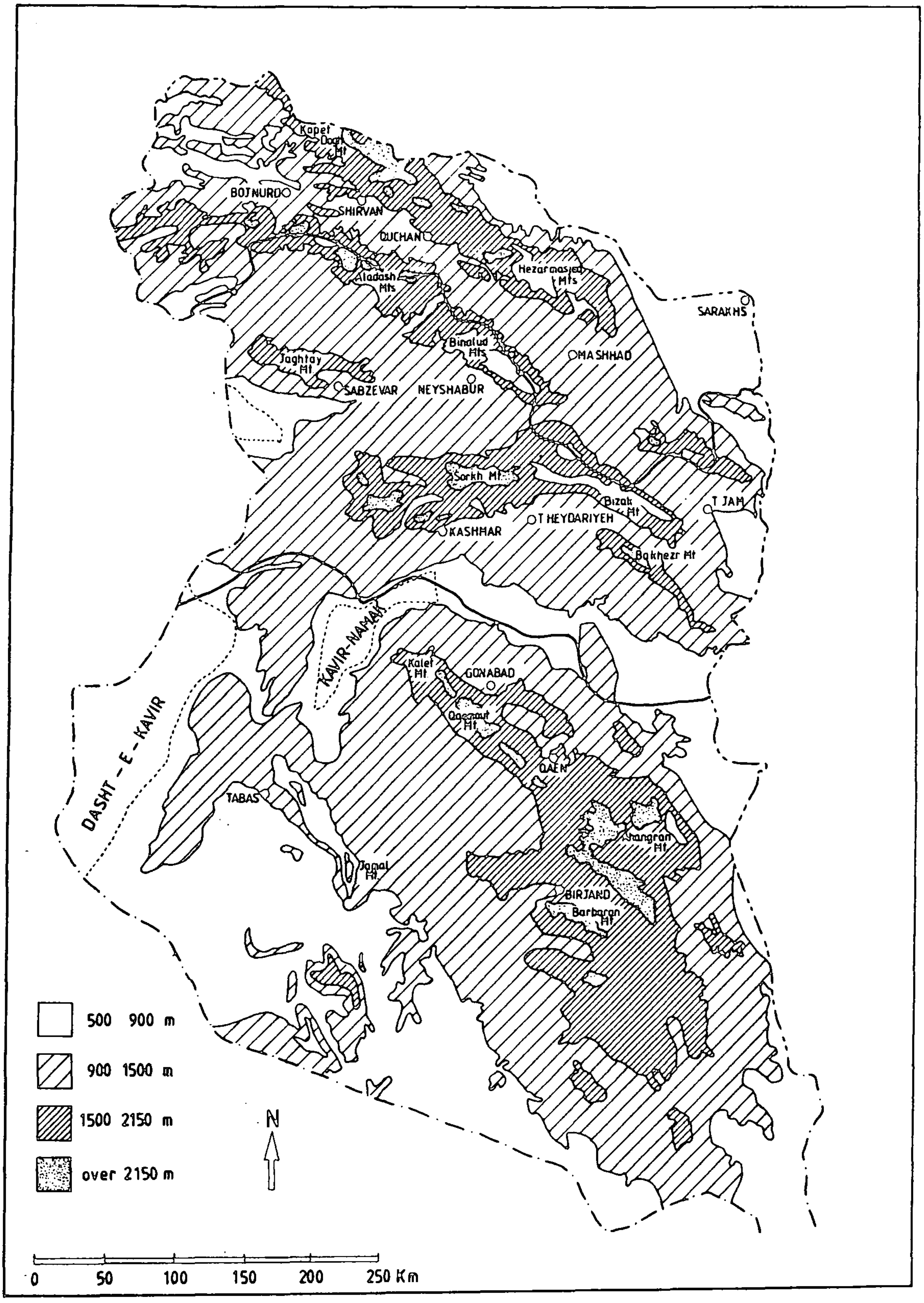


Figure 3.1 Topographical features in Khorasan (whole province).

most fertile and well watered plains of Khorasan, namely Bojnurd, Shirvan, and Quchan. These make up the lowland areas of the Atrak valley (lying approximately 900 to 1200 metres above sea level) with a gradual slope down towards the west.

Out of a total of 1099 villages in the Atrak valley (formed by the Shahrestans of Bojnurd, Shirvan and Quchan), 463 (42.1%) lie in lowland areas. (According to the village Gazetteer of Iran, a lowland village is described as a village where most buildings lie in lowland). From the maps of topography and settlement distribution (Figure 3.2), it is clear that the riverain areas of the Atrak to the east of Bojnurd, and particularly near the junction of the river with the Tabarik, Qoljoq and Chanaran tributaries, are most densely settled. In the western areas of Bojnurd the lowland villages are generally smaller and more sparesly distributed because although water is available the soil is less productive. Since the area of the Kashaf valley has the advantage of both dry and irrigation farming, the lowland villages here are relatively larger and more prosperous. Their average size, on the basis of the 1976 village gazeteer, ranges between 350 and 400, housing about 45 per cent of the Atrak valley's total rural population.

The upland villages (An upland village is defined as a village where most buildings are situated in the mountains) of the Atrak valley are slightly smaller in size (with an average population ranging from 300 to 350 and are more widely spaced (with an average spacing value of approximately 6.5 km compared to 6.3 km in lowland villages) and represent a larger proportion of the total (57.9% compared to 42.1% of the lowland villages). They are situated either on narrow alluvial

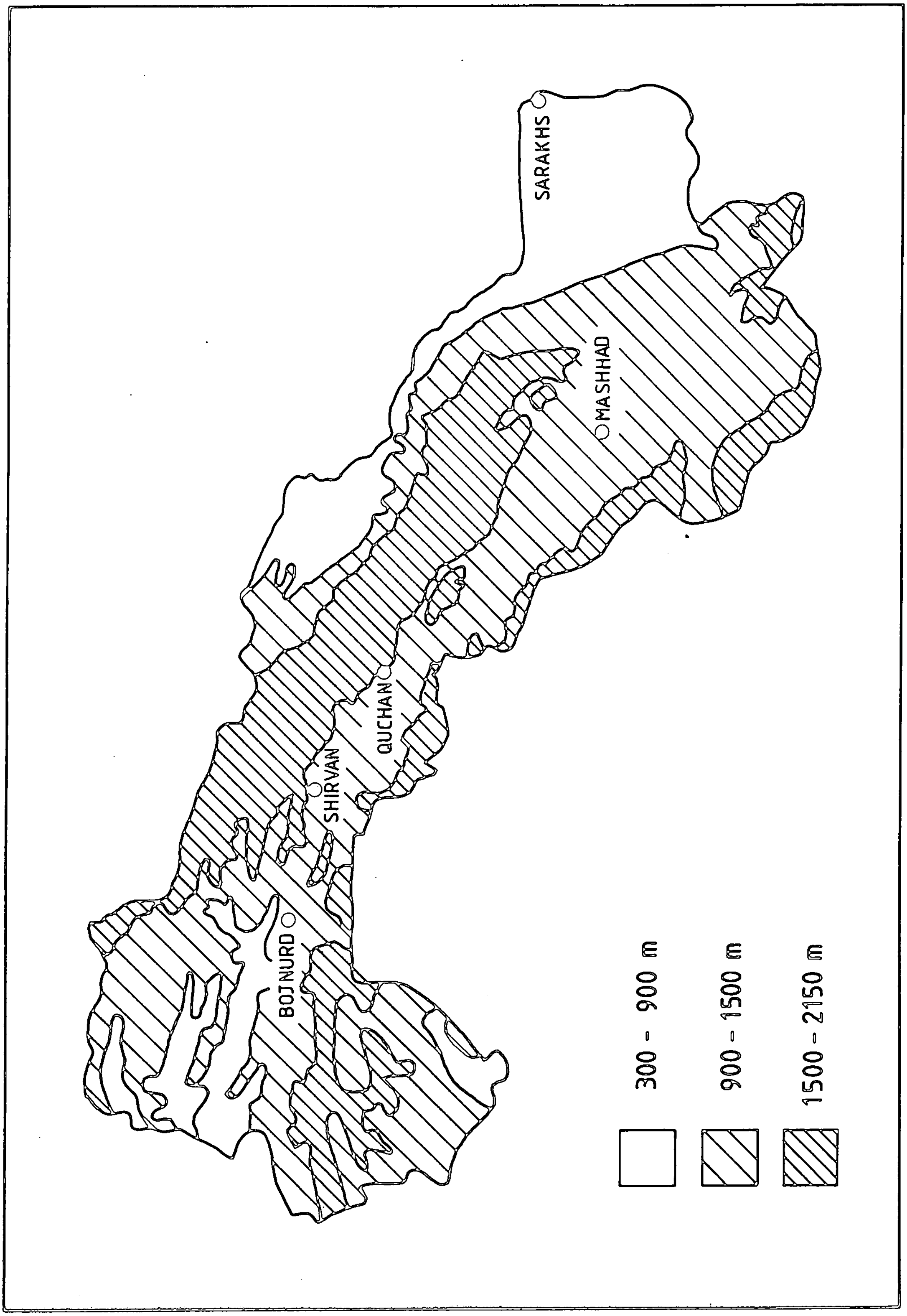


Figure 3.2 Topographic features of the north (with settlement overlay)

strips along the upland valley floors where the source of water is plentiful mainly from snow melt, or situated on the alluvial fans along the mountain foothills, where karstic springs and river networks are used as major water sources. The availability of these water sources, together with a greater amount of precipitation (about 300 to 400 mm annually), has resulted in the upland villages of this part of Khorasan being among the largest and most flourishing. This is evident from the fact that in 1976 the average size of the upland villages in the Atrak valley was greater than in any other region in Khorasan (Table 3.1).

Over the eastern part of the valley lies the large fertile plain of Mashhad between the relatively wide ranges of Hezar-Masjed in the north and Binalud in the south. To the east of Mashhad, the valley becomes wider, flanked by two smaller ranges namely Qarah-Dagh to the north and Shah Neshin to the south. These two minor ranges infact separate the Mashhad plain from the Sarakhs and Torbat-e-Jam lowlands respectively. The floor of the Kashaf Valley is approximately 900 to 1100 metres above sea level and has a gentle slope towards the east.

Unlike in the Atrak valley, most of the settlements in the Kashaf Valley (852 or 64.8 per cent of the total 1315 villages) are located in the lowland areas. This is by far the largest concentration of lowland villages in Khorasan. It alone constitutes 57.9 per cent and 20.2 per cent of the total lowland villages in the northern division and the province respectively. This however can be explained by firstly the extensivity of the plain which forms the Kashaf valley's floor, and secondly the greater availability of groundwater (about 850 million m^3 per annum), which is utilized as a supplementary source of water to a total of 1202 wells and qanats in the area. It is also for this latter reason that lowland villages in Mashhad area are generally larger and more closely spaced (being an average 510 persons and 4.9 km respectively) compared with 286 persons and 16.1 km for the province as a whole).

A comparison between the maps of topography and settlement distribution (Figure 3.2) suggests a compact linear type of settlement pattern, as seen in the settlements along the river banks of the Kashaf to the west of Mashhad. To the east of Mashhad the lowland settlements become fewer and less densely spaced. This is partly due to less productivity of the soil and partly due to loss of quality and quantity of the Kashaf's river water.

Upland villages of the Kashaf valley constitute 463 (35.2%) of the total of 1315 villages in the area. Larger and more densely spaced villages are found in the narrow upland river valleys which cut the northern flanks of Binalud mountains, namely Akhlamad, Golmakan, Zoshk and Torqhabeh. The upland villages located in these valleys are famous for their fruit production. They are large and utilise river and spring water, and supply the large market at Mashhad. Compared with lowland villages, the upland villages of this part of Khorasan are smaller in size and more widely spaced (being respectively an average of 210 persons and 7.2 km against 510 persons and 4.9 km in lowland areas).

Central division: Topographically the central division (the area between the Atrak-Kashaf valley and the Qaen-Birjand highlands) is characterised by mountain ranges which are irregular and broken; in contrast to the northern areas, the patches of agricultural land are scattered and poorly watered.

As Figure 3.3 indicates, the dominant topographical features of the central areas of Khorasan are the Kuh-e-Sorkh and Bizak mountains to the NW, NE and SE of which there are minor ranges respectively the Joghtay, Shah Nishin and Bakherz. The existence of these separate mountain ranges, which are also different in trend, has created a number of irregular basins in the area eg Neyshabur, Sabzavar, Torbat-e-Jam and Bakherz. The lowland areas of these basins reach their highest elevation east of Neyshabur, at about 1500 metres above the sea level. From here the lowland areas slope down both eastwards towards the Torbat-e-Jam and Harri Rud river bordering with Afghanistan, and westwards towards the Sabzavar and the Dasht-e-Kavir depression.

Approximately 68.9 per cent of the total of 2716 villages in the central areas of Khorasan lie on the lowlands. They are mostly clustered on the alluvial foothills or the upper areas of the basin plains where the conditions for agriculture are better. Good examples of compact clustered type lowland villages are found on the alluvial fans on the southern flanks of Binalud (eg Neyshabur plain) and Kuh-e-Sorkh mountains (eg Torbat-e-Haydariyeh and Kashmar plains). Towards the central areas of the basins the settlements generally become smaller and are more dispersed.

Upland villages of central Khorasan form 31.1 per cent of the total villages. They are located mostly in narrow alluvial strips on

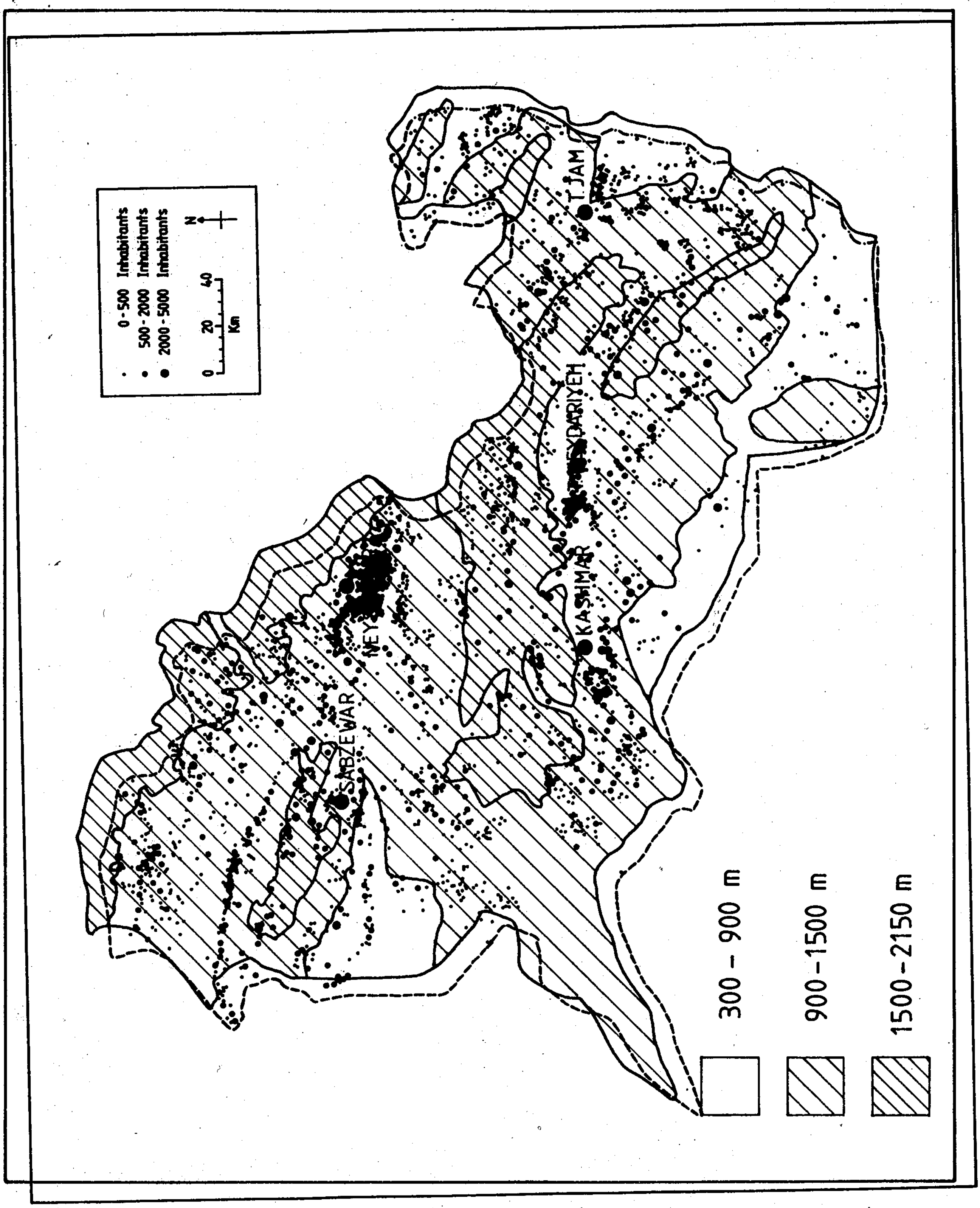


Figure 3.3 Topographic features of the centre (with settlement overlay)

hillsides and uphill valleys. A good example of such uphill valleys are those which cut the southern flanks of Binalud and Kuh-e-Sorkh and which act as a network of water courses descending into the immediate foothill plains of Neyshabur, Torbat-e-Heydariyeh and Kashmar (eg Kal-e-Salar, Bar,Shast-Dareh and Shesh-Taraz).

There are fewer upland villages than lowland ones and their average size is smaller (being respectively 31.1 per cent and 326.9 persons in comparison to 68.9 per cent and 334.9 persons in lowland areas); however, they tend to be also wider spaced (7 km compared with 6.5 m in the lowlands).

Southern division: The dominant topographical features of the southern areas of Khorasan are its highlands, which are surrounded by low flat desert areas of Dasht-e-Lut to the south, Dasht-e-Kavir to the west, Dasht-e-Naomid to the east and finally a narrow base and sandy desert land which separates the highlands of southern Khorasan from the massif of Kuh-e-Sorkh and also acts as a link between the two deserts of Dasht-e-Kavir to the west Dasht-e-Naomid to the east.

In general the highlands of southern Khorasan are lower and more broken then the northern ones. There are two separate mountain ranges in the area. To the east lie the Kuh-e-Kalat, Qaenat, Ahangaran, Momen Abad, and Shah ranges, covering a large area approximately 240 by 320 km sq trending in a NW/SE direction. Towards the east of these mountain ranges the area is occupied by a number of salt marshes which extend into the Dasht-e-Naomid along the border with Afghanistan. To the south, the highlands generally slope down towards the Dasht-e-Lut depression which lies at an elevation of about 450 metres above the sea level. The other range of mountains is situated adjacent to the Dasht-e-Kavir and extends almost parallel with the eastern ranges, although they are comparatively lower and less extensive. The most important of these are Kuh-e-Jamal, Marghob, and Nayband ranges (see Figure 3.1).

By comparing the maps of settlement and topography (Figure 3.4), it is clear that the areas of densest settlement are undoubtedly in upland areas, and in particular in the eastern highlands of Birjand and Qaen. This is also evident from the statistics (Table 3.1), which gives a percentage of 1802 or 66 per cent for upland villages of the southern areas of Khorasan. However despite a remarkable concentration of upland villages (approximately 47.5 per cent of the total 3791 upland villages of Khorasan), as a result of generally low altitudes, poor availability of rainfall and the absence of any significant river network descending from the mountains, the upland villages of this part of Khorasan are very small compared with the flourishing upland villages of central or northern areas of Khorasan. On the basis of the calculations from the village gazetteer data (1976), the average size of the upland villages of southern Khorasan is 101.2 persons which is very small in comparison to that of northern areas (298.3) and central areas of Khorasan (326.9).

Because of the absence of any surface water in the lowland areas, together with low productivity of the soil and the smallness of the groundwater reservoir the lowland villages of southern Khorasan are fewer (only about 34 per cent of the total settlements). Compared with the central and northern divisions, the lowland villages, are much smaller in size (an average size of approximately 168.6 persons in comparison to 298.9 in the north and 334.9 persons in the central division). On average they are spaced almost three times further apart than those of the central and northern areas of Khorasan (16.1 km, against 5.9 km and 6.5 km respectively).

SOILS

To a large extent the land use and settlement patterns in Khorasan are affected by soils. In this section the land use capability of the soils and their impact on the settlement patterns are discussed. The study is mainly based on the soil potential map of the region (Figure 3.5) and the reports made by the Ministry of Agriculture and Natural Resources. However, to summarise and simplify the study here the soils are classified into three major groups (i) soils with good to moderate potential agricultural land use (ii) soils with moderate to low potential agricultural land use and (iii) soils with low to no potential agricultural land use. These classifications are chosen because they correspond with those used by the Ministry of Agriculture (Ministry of Agriculture and Natural Resources : National cropping plan, 1975, Vol 2, pp.1-18).

Soils with good to moderate potential land use : In Khorasan, the soils classified in this group are fine textured alluvium, saline alluvium, brown and chestnut with sierozems and grey and red desert soils. These soils cover a total area of about 9,149,000 ha or 29.2 per cent of the provincial land area. As can be seen from Figure 3.5 these soils are mostly found in the north and in small areas of Central Khorasan where the amount of rainfall is higher and drainage areas are more adequately supplied. Brief, general characteristics of each of these mentioned soils are now described:

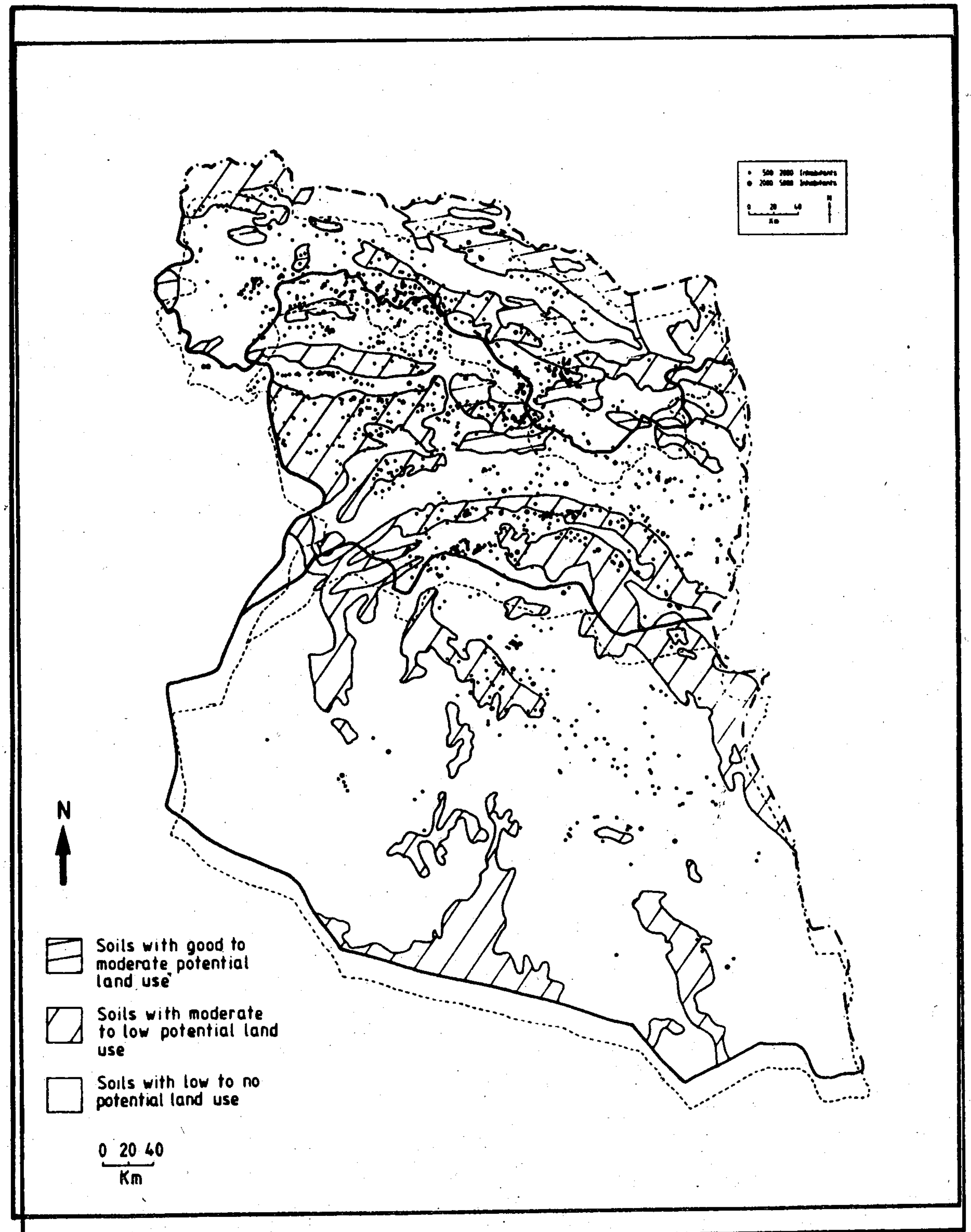


Figure 3.5 Generalised soil potential map of Khorasan.
(with settlement overlay)

Fine textured alluvium - These soils are developed in the plains and valleys which are relatively well drained. The deposited sediments of these soils are young and formed by the running and flooding of water from mountains. Although the areas covered by these soils are small in Khorasan (3.7 per cent of the total land area), in terms of land use they are the most fertile. They have few limitations of salinity and therefore can be used for dry farming cultivation. In Khorasan the largest area of alluvial soil is found in Mashhad, and also in small scattered areas of the central basins, notably in Neyshabur, Torbat-e-Jam and eastern areas of Kashmar Shahrestan.

Saline alluvial - These soils are developed in poorer drainage areas of Khorasan, notably along the eastern boundary with the USSR, in Sabzevar, and also in the scattered smaller areas to the south of Gonabad, eastern Kashmar and Qaenat. However as soils are not highly saline, irrigation is possible by qanat. In Khorasan the saline alluvial soils cover approximately 1,098,000 ha (3.5 per cent of the provincial land area) and are mainly used for cultivating wheat, barley, sugar beet and cotton.

Brown soils - These soils are highly calcareous. They are predominantly found in the semi-arid areas of Dargaz north of Khorasan. Their limitation is due to a deficiency of water in summer months. In Khorasan brown soils are mostly used for the dry-farming of wheat and barley. A particularly good yield of these crops are usually found in areas of Dargaz where supplementary irrigation is provided by the river Dorungar. The approximate area of these soils in Khorasan is 1,600,000 ha or about 5.1 per cent of the total land area of the province.

Sierozem - These soils are powdery and often become boggy after rain. They are characterised also by a shallow humus horizon (usually 5 to 10 cm depth), which is usually underlined by calcareous limestone. Sierozem soils cover approximately 5,080,000 ha or 16.2 per cent of the provincial area. They are mostly distributed in eastern and central parts of Khorasan. In terms of land use, although they perform poorly under dry farming, they have good potential in areas where drainage is adequate, or heavy irrigation is provided by qanats so that the salt content on the surface is reduced.

Grey and red desert soils - These are highly calcareous soils which are developed in arid regions of Khorasan. They have limited potential due to their low moisture and organic content. In Khorasan grey and red desert soils are mostly found in the central areas, covering approximately 410,000 ha or 1.31 per cent of the total provincial area. Inadequate rainfall prevents dry farming crop production on these soils. However, they have proved to have a high potential in areas where irrigation from qanats is possible, a good example being near Kashmar and Neyshabur.

Soils with moderate to low potential land use : Soils classified in this group are Sierozem/reogols, desert soils and coarse textured alluvial and colluvial soils. They occupy approximately 4,030,000 ha (12.9 per cent of the total provincial land), mostly distributed in the central and eastern part of Khorasan, and usually adjacent to the desert soils which severely limit agriculture.

Sierozem regosols - These soils are young and their profiles are generally undeveloped. They contain a high proportion of sand and gravel and therefore are highly permeable. In Khorasan the area covered by sierozem/regosols is relatively large, approximately 2,270,000 ha, most of which is distributed in central and southern areas. In areas of Khorasan where groundwater is available in large quantities, these soils have good potential for production of deep-rooted crops as has been proved in Kashmar, which is famous for grape production.

Coarse textured alluvial and colluvial soils - In Khorasan, there are almost 360,000 ha of these soils. They are found in the foothill fan areas formed as a result of the building up of materials carried by flood water from the mountains. The main materials are gravel, sand and clay which are usually cemented by limes. This results in stony surfaces which have a very low agricultural potential in their present state.

Soils with low to no potential land use : As can be seen from Table 3.2 approximately 18,120,000 ha or 57.9 per cent of the total land area of Khorasan is covered by this category of soil. These are usually in the form of sand dunes, salt marshes, bare mountains, rocks, and steep slopes. These surfaces usually have no agricultural potential, especially the poor desert soils such as desert seirozem, solonchak and lithosol. Generally speaking, these soils suffer from aridity, salinity and erosion which reflects the marked arid climate conditions of the area. However, since these mentioned limiting factors are more pronounced in the southern areas of Khorasan they are therefore predominant here.

By comparing the maps of soil group potentiality and settlement distributions (settlements with a population of 500 to 5000) (Figure 3.5) it is clear that the settlement pattern and sizes are greatly

Table 3.2 Soil classifications - Khorasan according to the National Cropping Plan (1975)

	Area (000 ha)	Percentage
Soils with good to moderate potential land use	9,149	29.2
Soils with moderate to low potential land use	4,030	12.9
Soils with low to no potential land use	18,120	57.9

Table 3.3 Number and distribution of the Meteorological Station by regions

Area	Synoptic	Climatological	Rain Gauge
North	1	23	26
Central	2	6	26
South	2	12	21
Khorasan	5	41	73

Source : Plan Organization 1972b

affected by the character of the soil and its potential for agriculture. A higher concentration of settlement is found in areas of soils with good to moderate agricultural potential, particularly in those places where the productivity of the soils are increased by the supplementary source of groundwater resources such as in Mashhad, Neyshabur, Esfarayen, Torbat-e-Jam and Kashmar. There are fewer settlements in the western and southern areas of the province, where the soils suffer from aridity, salinity and erosion.

CLIMATE

Introduction : Table 3.3 shows the number and distribution of the meteorological stations in Khorasan. It is clear from this Table that the number of meteorological stations are limited to 119, of which 73 are merely rain gauge, 41 climatological and only 5 synoptic. Indeed the insufficiency of the number of these stations becomes clearer if one bears in mind the extensive area of the region and its remarkable physiographic and topographic diversity. Furthermore, these stations are only distributed in the highly populated areas and thus there is little or no meteorological information available for the isolated areas of uplands and deserts which not only occupy a vast area of the region but also have a dominant role in the climatic diversity of the region. Moreover, a great majority of these stations are newly established and it is therefore not possible to obtain very much long term recorded data.

In the following discussion, the climate of Khorasan is analysed according to pressure and winds, temperature, precipitation and relative humidity. The most important of these is precipitation when considering settlement patterns.

The following study is based on post 1958 data for six main stations in the study area, five of them being synoptic. Mashhad and Bojnurd are located in the north, Torbat-e-Heydariyeh and Sabzevar in the centre and Tabas and Birjand in the south of Khorasan. These stations have been selected as they have a relatively longer history of recorded data, they are well distributed and they are relatively more reliable in terms of the quality of their data.

Pressure and winds : In Winter, Khorasan falls under the influence of two major pressure systems : the polar continental high pressure centred over Siberia, and the low pressure systems over the Mediterranean Sea, Cyprus and the Persian Gulf. The outflow from the Siberian anticyclone passes over the region towards the low pressure which has formed over the Persian Gulf at this time. Consequently, the prevailing winter winds in Khorasan are from NE to SW. Because these north easterly winds are of a continental origin, they are cold, dry, and bring no precipitation. However, occasionally the relatively warm and damp air which originates over the Mediterranean Sea manages to get through and interrupts the dry and cold effect of this anticyclone by bringing rainfall and raising temperature conditions.

During the summer Khorasan falls between higher pressure to the north and the low pressure system centred over western India. As a result the summer winds prevail over the region in a NW-SE direction. A characteristic of these winds is that they are hot, dry and blow with high velocity. These characteristics are particularly intensified in southern Khorasan, as the area is more closely situated to the centre of low pressure and a considerable proportion of it is open desert without any vegetation cover or mountain barrier. Here, these winds are localled called "Bad-e-Sad-o-Bist Ruz" translated as "winds of 120 days". This is because its appearance is fairly constant, usually from the end of May until the end of September. With their high velocity, measured to as high as over 100 miles per hour, they can have a disastrous effect on agricultural activity. They can damage or destroy the vegetation and plants, cause soil erosion and, above all, carry sands and dust resulting in problems of desertification.

Annual Temperatures : Both latitude and topography play an important part in the distribution of annual temperature conditions in Khorasan. The effect of latitude is clear by comparing the average temperature conditions in northern, central and southern stations. As can be seen from Table 3.4 the temperatures increase towards the south. However, it should also be pointed out that the quality of increased temperature from north to south is not the same everywhere and is modified by local topography. For instance, Sabzevar at the margin of the Dasht-e-Kavir has higher temperatures than Torbat-e-Haydariyeh which is further south. One obvious explanation is that the latter has a much higher elevation (1,333 m above sea level compared with 940 m at Sabzevar). A similar situation also exists between the two southern stations of Tabas and Birjand. The mean annual temperature in Khorasan ranges between -1.2 and 24.3°C in Bojnurd and 7.8 and 33.7°C in Tabas. However, due to the continentality of its climate, the annual range of temperatures within the region is considerable. Sabzevar in the central region has the highest recorded mean annual range of temperature with approximately 26.4°C. As the elevation and the average percentage of relative humidity decreases towards the south and the desert areas the gap in the

Table 3.4

Average Temperatures in Khorasan

STATION	Elevation (metres)	Average Mean Temperature (C) J	F	M	A	M	J	J	A	S	O	N	D	Range (C)
Bojnurd (N)	1,100	-1.2	1.8	6.6	11.4	17.2	21.7	24.3	22.7	18.6	12.2	6.1	1.6	25.5
Mashhad (N)	985	1.9	3.9	8.5	13.5	18.9	23.8	25.9	24.2	19.7	13.8	7.4	3.4	24.0
Sabzevar (C)	940	2.9	6.1	10.9	16.4	22.4	27.2	29.3	27.5	23.3	17.3	9.6	4.5	26.4
Torbat-e-H. (C)	1,330	1.6	4.0	8.4	14.1	19.9	24.5	26.4	25.0	21.0	14.9	8.1	3.6	24.8
Birjand (S)	1,455	5.4	7.3	12.3	16.9	22.3	26.7	28.3	26.7	23.1	17.8	10.5	6.2	22.9
Tabas (S)	691	7.8	10.6	15.8	20.8	26.7	31.6	33.7	32.0	27.9	21.8	13.9	8.6	28.9

(N) = Northern region (C) = Central region (S) = Southern region

Source : Iran Meterological Reports (1958-1976) temperature between the coldest and warmest months of the year (January and July) reduces, recording 22.9°C at Birjand..

In winter, the climate in Khorasan is very cold and the ground surface is either frosty or muddy. The cold winter is particularly felt in the northern areas of Khorasan where the presence of high relief intensifies the effect of the cold north easterly airflow. In some localities such as Bojnurd and Quchan the recorded mean temperature in January usually falls below freezing point. However, as the data indicates (Table 3.4) winter temperature increases towards the south and south west, partly due to the decreased latitude and altitude and partly due to greater remoteness from the cold air mass of the Central Asian high pressure. Accordingly, Tabas in the south west is the warmest place of Khorasan in winter with a recorded average mean temperature of 7.8°C in January. Even here, though, temperatures often fall below freezing point and frost can be present for some two months.

By around mid March the effect of the cold winter is considerably reduced and bright sunshine and the rise in temperature signifies the approach of spring. Although spring is of short duration and is regarded as a transitional season, it can be distinguished by its temperature. As Table 3.4 indicates, the temperature conditions in April are less extreme than those of winter or summer. In the early spring, frost is still common in the upland areas. Away from the mountains and towards the desert areas the spring temperature increases.

Summers in Khorasan usually start at about the end of May when the effect of the Siberian anticyclone is reduced and the low pressure system which is re-established by this time over western India dominates the climate. Throughout the summer, as a result of high amounts of insolation (radiant energy received from the sun), the rise in the temperature is considerable. In the hottest months of the season (July and August) human activity is extremely restricted in some critical hours in the afternoon by the extreme heat.

The distribution pattern of summer temperature conditions is similar to other seasons; that is the temperature is lower in the north than the south. Again, this is only a general trend as in some localities the pattern may be eclipsed by the effect of local elevation and topography. July is the warmest month of the season. Bojnurd and Mashhad have the lowest July temperatures with average means of 24.3°C and 25.9°C respectively while, by contrast, Tabas and Birjand record the highest levels with 33.7°C and 28.3°C respectively.

Similar to spring, autumn is a short season from mid September to mid November. At the beginning of this season thermal conditions over the region are generally moderate and pleasant. The average mean for October ranges between 12.2°C at Bojnurd and 12.8°C at Tabas. Towards the end of Autumn, however, the temperature suddenly reduces over the region as the polar continental cold air begins to dominate, producing a cold winter.

Annual precipitation : While Iran ranks among the most arid countries in the world, it receives an average annual total of 100mm more rainfall than occurs in Khorasan. One explanation for such a comparatively small amount of rainfall in Khorasan is that the region is isolated from the effect of 'Mediterranean' and 'Caspian' moisture by the geographical barriers of the Zagross and Alburz mountains.

Because of its marked aridity, the amount of annual precipitation in Khorasan varies markedly from one year to another. This relatively high fluctuation makes average summaries of precipitation almost valueless. Figure 3.6 shows the variation more clearly with deviation charts based on normalised values (standard deviations from the mean). When supplemented with five year running mean charts (Figure 3.7) the effect of variation through time is even more apparent. It can be noted, for example, that all of the synoptic stations display similar climatic trends with a gradual decrease in annual totals to 1964 followed by a steady increase to 1970, and then a small trough and rapid increase. In making these generalisations, one must note that the period after 1967 was distorted by the consistently wet years experienced in 1968, 1972 and 1976. These variations are similar in the country as a whole. As indicated by the rainfall maps of the region (Figures 3.8, 3.9 and 3.10), only a small proportion of Khorasan (mainly near Bojnurd and Quchan to the north west) receives an annual amount of over 400 mm. The Kashaf valley in the north east and the highland areas of the centre and south of Khorasan receive between 200 to 300 mm and the remaining areas, including marginal desert areas surrounding the highlands of Birjand and Quchan as well as the extensive desert areas to the west and south, normally receive less than 200 mm of precipitation per annum.

The important role of topography, in the distribution of precipitation is clear by comparing the maps of rainfall and topography (Figures 3.1, 3.8, 3.9 and 3.10). As illustrated, by decreasing the

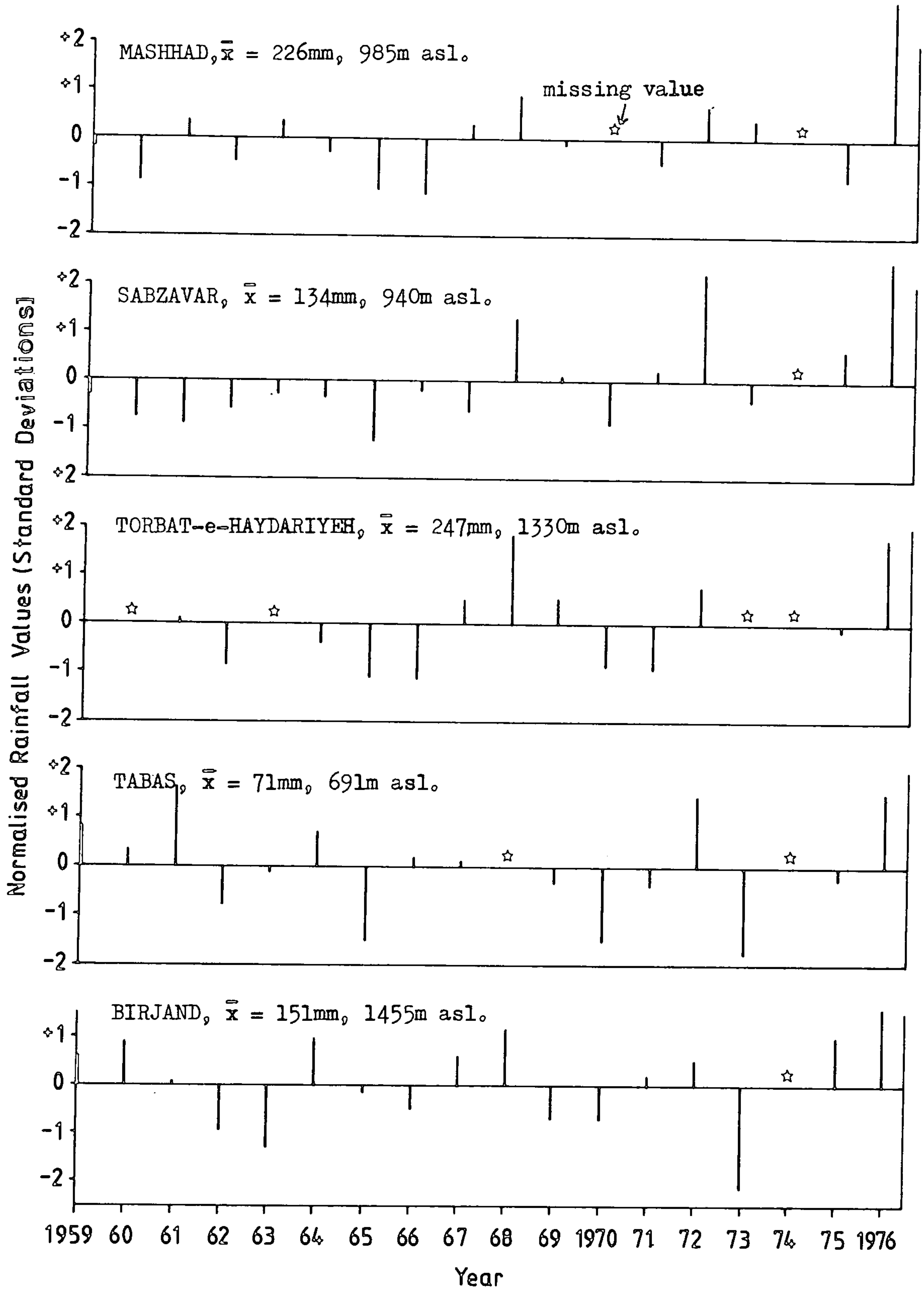


Figure 3.6 Rainfall deviation charts for synoptic stations in Khorasan.

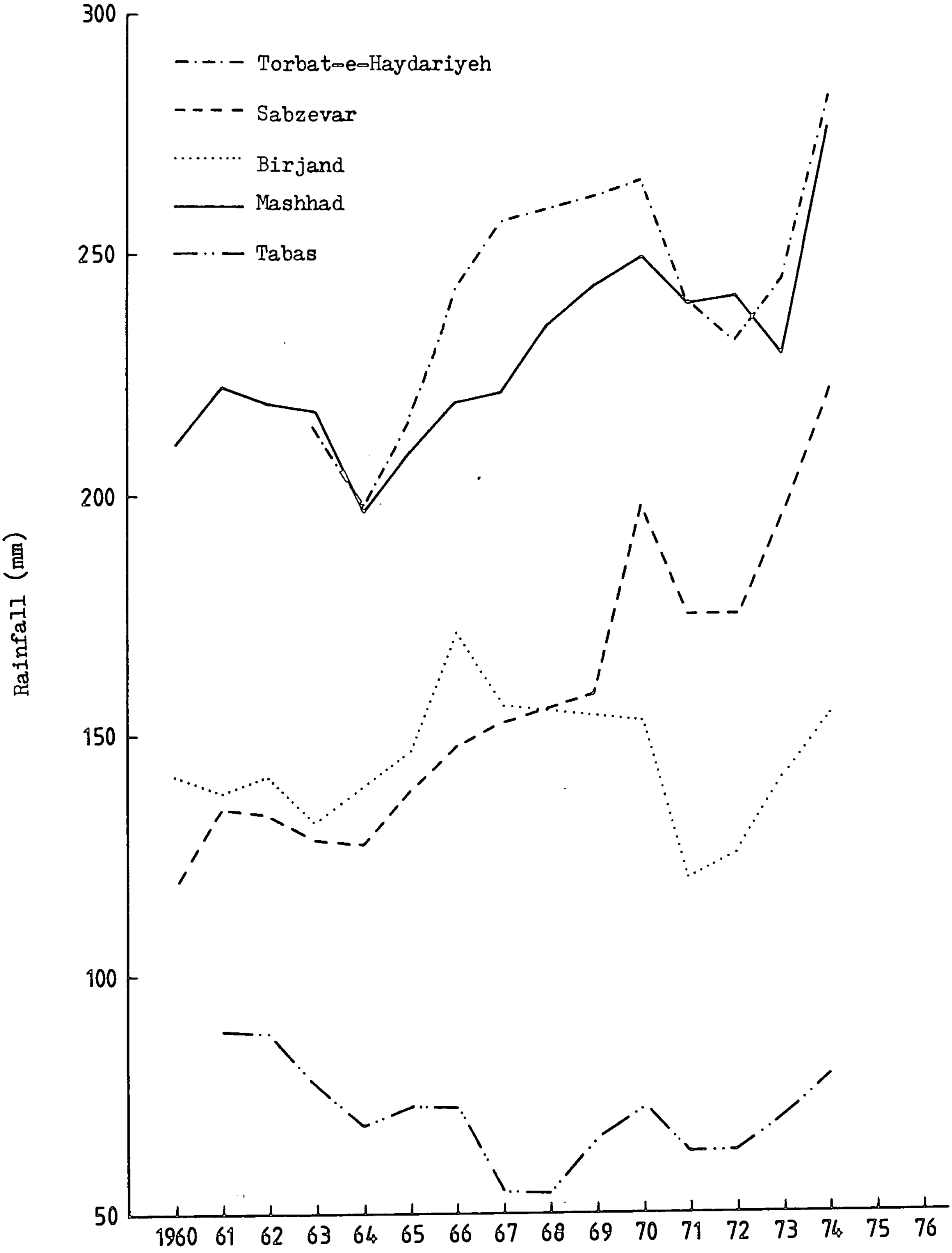


Figure 3.7 Five-year running rainfall means for synoptic stations in Khorasan.

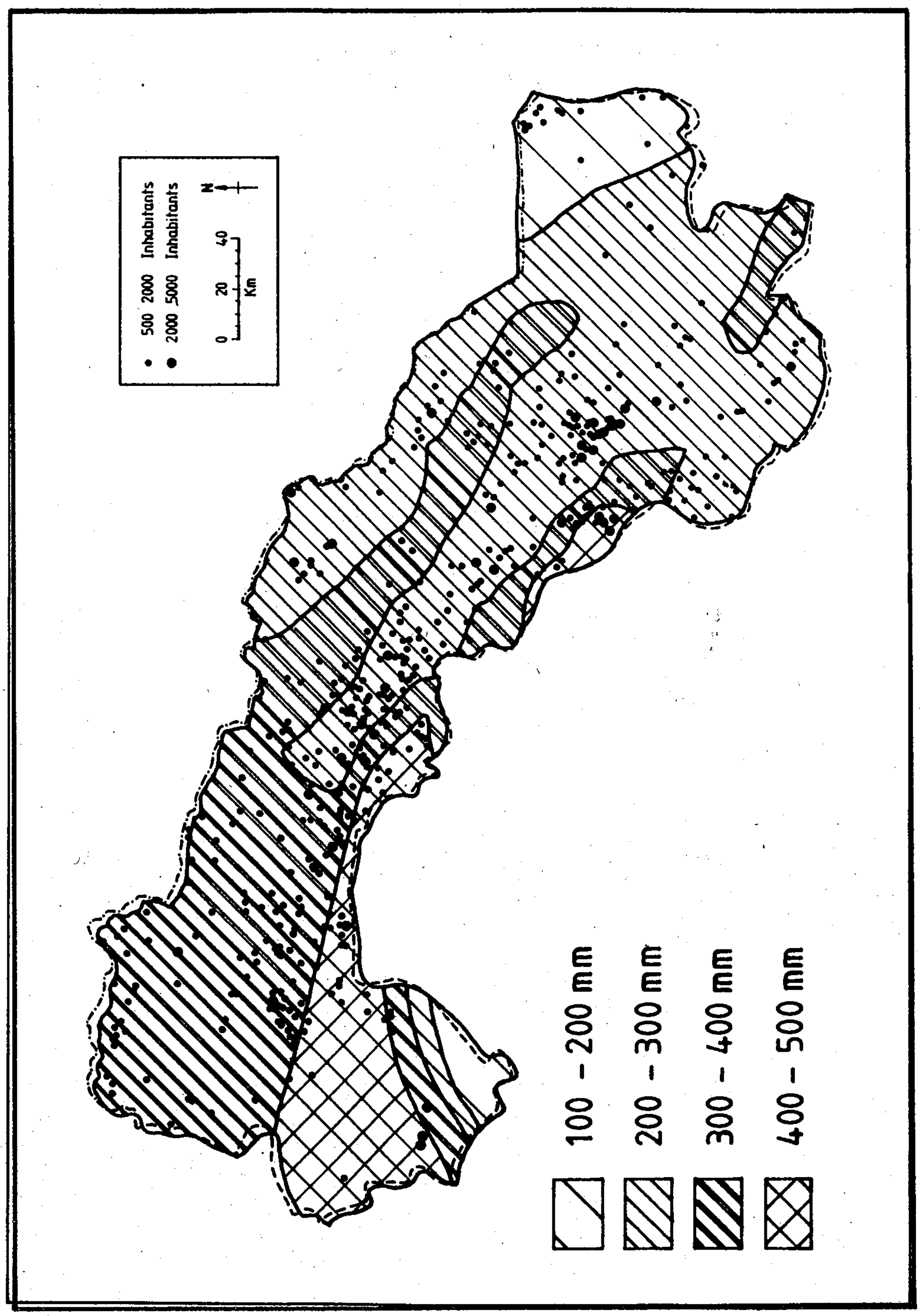


Figure 3.8 Annual average rainfall in the north (with overlay of LARGE settlements).

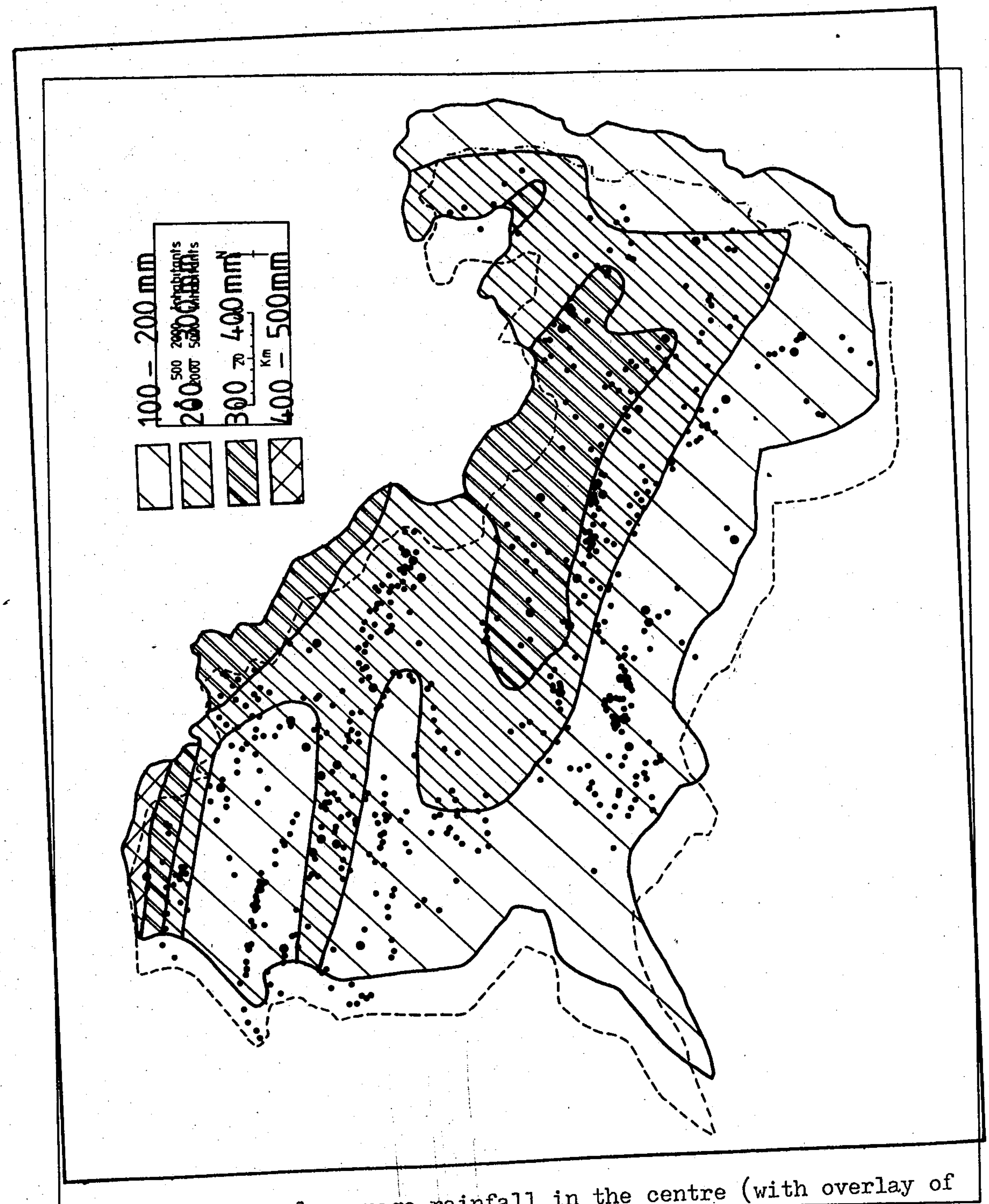


Figure 3.9 Annual average rainfall in the centre (with overlay of LARGE settlements).

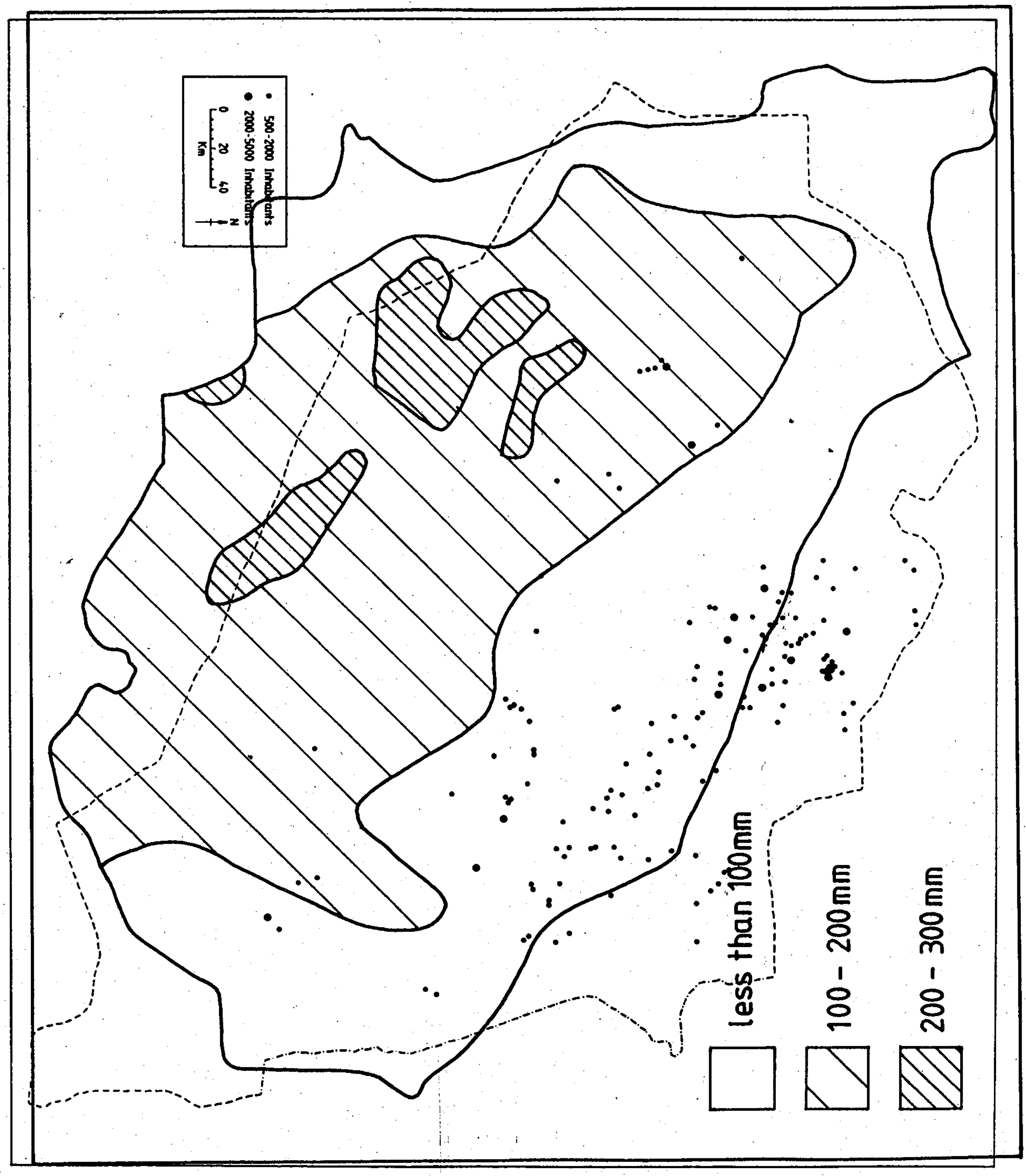


Figure 3.10 Annual average rainfall in the south (with overlay of LARGE settlements).

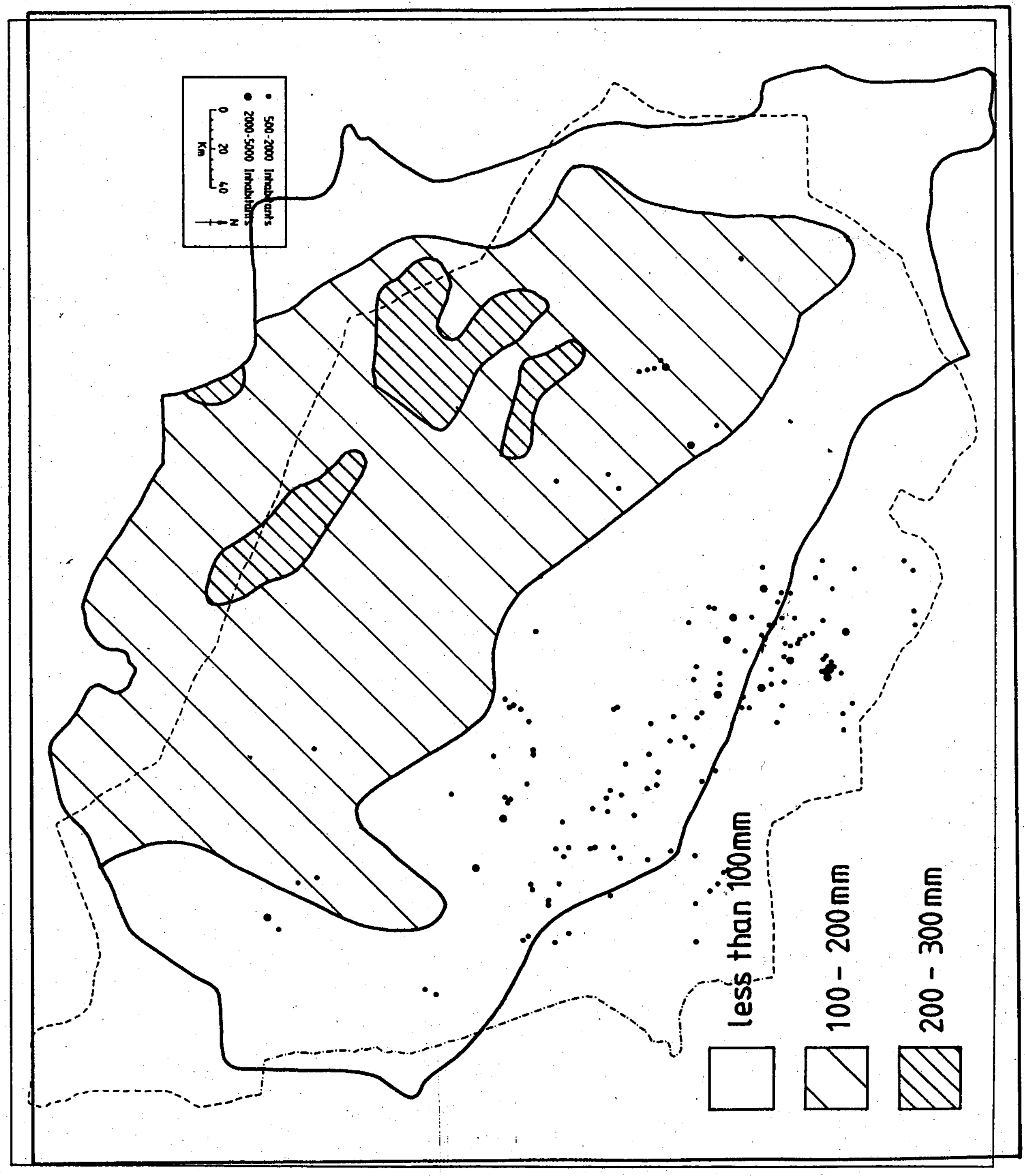


Figure 3.10 Annual average rainfall in the south (with overlay of LARGE settlements).

altitude from north to south the annual amount of precipitation generally decreases. Away from the mountains and highland areas of the central and southern regions the amount of precipitation reduces abruptly and is reflected in the presence of the surrounding deserts.

In winter, Iran owes much of its precipitation to the moisture sources in the Mediterranean. Although the effect of this source is much reduced by the time it reaches over the eastern part of the country (owing to presence of Alburz and Zagros barriers and the increased distance from the origin of the source), nevertheless, as far as precipitation is concerned, its occasional appearance brings a favourable change into the region. As shown by Table 3.5, it is during the winter months that every given station in Khorasan receives at least half of its total annual precipitation, much of this being in the form of snow.

Spring, although a short season, is the time when highland areas of Iran, including Khorasan receive a great deal of convectional rain. The longer days and bright sunshine produce considerable heating of the ground surface and increase thermal conditions resulting in convectional rainfall. This type of rain usually occurs in short, powerful bursts in the afternoon or early evenings; it is often accompanied by thunder. The timing of this rainfall is valuable for plants.

Available data (Table 3.5) shows that between 20 and 25 per cent of the spring precipitation falls during April; only Tabas does not have its highest monthly rainfall at this time. In Bojnurd the amount of rainfall in April is as high as 51 mm, which approaches the annual total

Table 3.5

Precipitation in Khorasan

STATION		Elevation (metres)	Average Rainfall (mm)													Standard Deviation
			J	F	M	A	M	J	J	A	S	O	N	D	Year	
Bojnurd	(N)	1,100	21	20	34	51	27	7	5	4	3	15	18	17	205	*
Mashhad	(N)	985	21	25	48	56	24	3	1	0	1	13	18	17	226	67.3
Sabzevar	(C)	940	26	16	25	27	14	2	1	0	0	4	10	20	134	161.7
Torbat-e-H.	(C)	1,330	44	43	44	53	17	1	0	0	0	4	13	28	247	247.5
Birjand	(S)	1,455	30	28	25	38	8	0	0	0	0	3	6	13	151	147.5
Tabas	(S)	691	11	14	15	11	4	0	0	0	0	1	7	8	71	75.9

(N) = Northern region (C) = Central region (S) = Southern Region (*) Insufficient Data

Source : Iran Meteorological Reports (1958-1976) for Tabas. The amount of spring rainfall decreases from north to south and from east to west.

Throughout the long summer period over much of Iran including Khorasan, the sky is clear and it is only seldom that rain bearing clouds appear over the highland areas and in this case only a negligible amount of convectional type rain occurs. The amount of summer rainfall (June to September) in the most rainy station of Khorasan, Bojnurd, is as low as 19 mm or only 9 per cent of the annual total. The most arid station, Tabas, normally receives no summer rainfall.

Iran's long dry summer season ends by mid September, when the depression centred over Cyprus and the Mediterranean Sea begins to re-establish. However, it is not until mid October that the cyclonic depressions are able to extend their influence over the eastern parts of Iran. During the Autumn the only noticeable rainy areas of Khorasan is in the northern division. Over the remaining areas of Khorasan, the amount of rainfall is negligible. Among the selected stations, Bojnurd with approximately 33 mm has the highest amount of Autumn (October and November) precipitation. Mashhad and Torbat-e-Heydariyeh receive lesser amounts between 31 and 17 mm and finally Birjand and Tabas are the driest ones with an average Autumn precipitation of 9 mm and 8 mm respectively (Table 3.5).

Relative Humidity : The shortage of rainfall, remoteness from the sea and the lack of any significant surface water, together with the fact that a large proportion of the region is virtually desert have resulted in a low relative humidity over the region. The average relative humidity among the given stations is very low and rarely exceeds 60 per cent. On the whole it can be said that the percentage of relative humidity is higher in the north and decreases southward.

Throughout the winter months, due to the occasional effect of moisture-bearing winds from the Mediterranean Sea, the percentage relative humidity is highest, while in the summer, due to the absence of rainfall and the prevailing hot-dry north westerly winds the humidity is very low, particularly in the southern areas where the above mentioned factors are generally more pronounced.

The relationship between rainfall and settlement patterns is evident, albeit superficially, from the data and figures presented and when compared with the settlement distribution maps (Figures 3.2, 3.3, 3.4, 3.8, 3.9 and 3.10). A more detailed examination is presented in subsequent chapters with reference to water supplies. Some of the relevant hydro-geological background is first presented to allow a more varied understanding of the relationship between settlements and water supplies.

HYDROGEOLOGY

The hydrogeological significance of the major rocks and their effect on settlement pattern in each major division of the north, central and south is examined. The study is based mainly on the geological map of Iran (1:250000), Hydrogeological map of Iran (1:250,000), and the available reports made by the Ministry of Agriculture and Water Supply.

Northern Khorasan: Hydrogeologically, the northern areas of Khorasan differ from the rest of the province. The differences are partly due to the prevalence of extensive and highly permeable Cretaceous limestone in the area (Figure 3.11), and partly due to the higher rate of precipitation. The Cretaceous limestone forms the mountains of Allah Akbar and Hezar-Masjed which form the northern ranges of the Atrak-Kashaf valley. A characteristic of these rocks is that they are frequently fractured and perforated, and therefore play a positive role in the development of groundwater resources both in uplands and lowlands. In upland areas the fractured limestone results in the creation of many karstic springs upon which many of the 1144 upland villages in the area are dependent. By stopping the water they also become a good source of recharge for an underground water reservoir, which, as is explained in later chapters, has a decisive role in the location and pattern of settlements in lowland areas.

Unlike the limestone of the Cretaceous, the rocks of the Jurassic (schists, sandstone, and limestone) which cover the upland areas of the south of the Atrak-Kashaf valley have little or no positive effect on the development of groundwater resources, as they are mainly in compact form. However, in some areas where the limestone and schists are fractured (as for example between Neyshabur and Mashhad), they are regarded as a semi-aquifer (Ministry of Water Supply, 1972).

Alluvium is widespread in the area. It covers the compact Palaeocene conglomerate which underlies the plains in most places. The deposited materials are derived from the upland areas, either through erosion or fluvial activity. Hence, schist, sandstone, and limestone

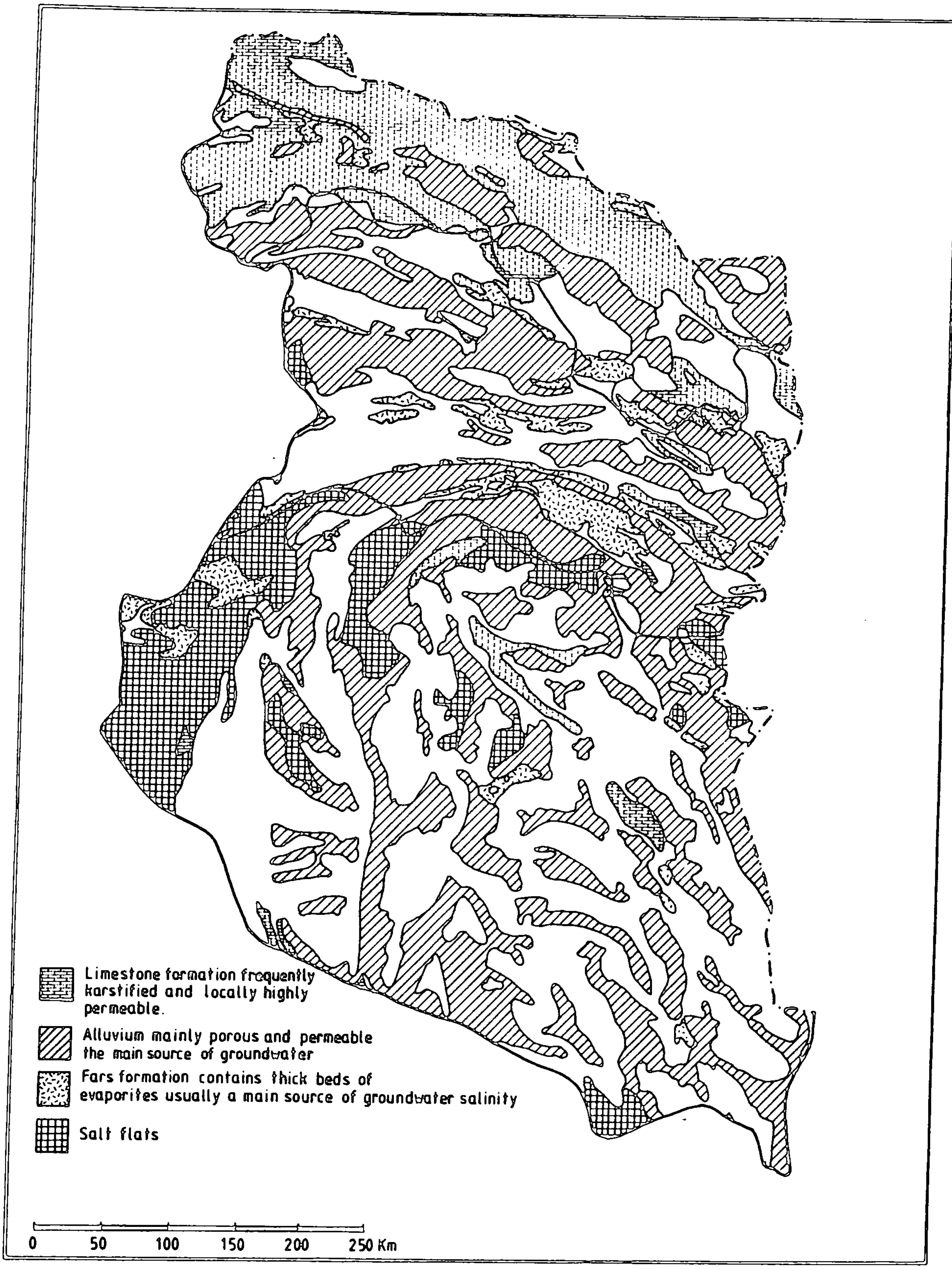


Figure 3.11 Generalised geology of Khorasan.
(based on Huntings report to the Ministry of Agriculture and Natural Resources - 1975)

materials of Jurassic age cover the Valley's floors adjacent to the Southern range and the predominantly limestone of Cretaceous age is found adjacent to the Northern range.

The intermontane plain of Mashhad has the thickest and timeless alluvial deposition. The thickness of the alluvium is highest at the foot of the Hezar Masjed mountains north of Mashhad (approximately 300 metres). Here, the alluvial fans are composed of mainly course material and therefore the losses to the groundwater are high. Towards the central areas of the plains the depth of the alluvium reduces sharply and in fact in some places of the central Bojnurd and Mashhad plains the compact Palaeocene conglomerates (laid during the late Tertiary era) which forms the base of the plains are seen in the surface. The alluvium covering the lower parts of the Atrak-Kashaf valley's floors are mainly formed by the river Atrak and Kashaf. With the exception of riverain banks, the deposition in most lower parts of the plains is fine grained and therefore has no significant effect on the development of groundwater reservoirs.

In summary it can be said that the Cretaceous limestone and alluvial fans are the main sources for the tapping of groundwater resources in northern Khorasan. However it should also be noted that the rivers Atrak and Kashaf, as well as the numerous unlined irrigation division channels diverted from those rivers, carry water to the remote parts of the plains and also make a remarkable contribution to the groundwater recharge. According to SCET Coop (a group of French engineers studying the area of Khorasan) in Mashhad plain alone about 850 m^3 of water are tapped annually which is exploited by 1202 water supply points (wells and qanats) in the area. If one compares this total of 1202 water points with the 852 villages in the lowland areas, then the dependency of the villages on the groundwater resources becomes clear.

Central Khorasan : As already stated central Khorasan is occupied by a number of Tertiary and Quaternary basins. The basic environmental characteristics of Iran's endoric basins has been described by the model of Bowen-Jones (1968). In the following study of hydrology and its relation with settlements we examine the environmental characteristics of the central basins of Khorasan in accordance with the four classified zones suggested in the model. The schematic plan, cross-section, and the principle characteristics of such basins are given in Figure 3.12.

ZONE A: This is a zone of mountains and hills where mechanical and sub-aerial erosion are dominant. Unlike the Mesozoic origin of the northern mountains of Khorasan, the upland areas of central Khorasan were formed during the last tectonic movements which took place during late Tertiary and early Pleistocene. Thus, the series of marls, sandstones and conglomerates respectively from Eocene, Miocene and Pliocene periods are the most extensive and widespread formations in the area. A characteristic of these rocks is that they are dense, consolidated and unlike the permeable limestones of the northern mountains of Khorasan have little positive effect on the development of groundwater.

ZONE B: This is a zone of alluvial fans situated at the immediate margin of the upland areas. The sediments forming the alluvial fans are

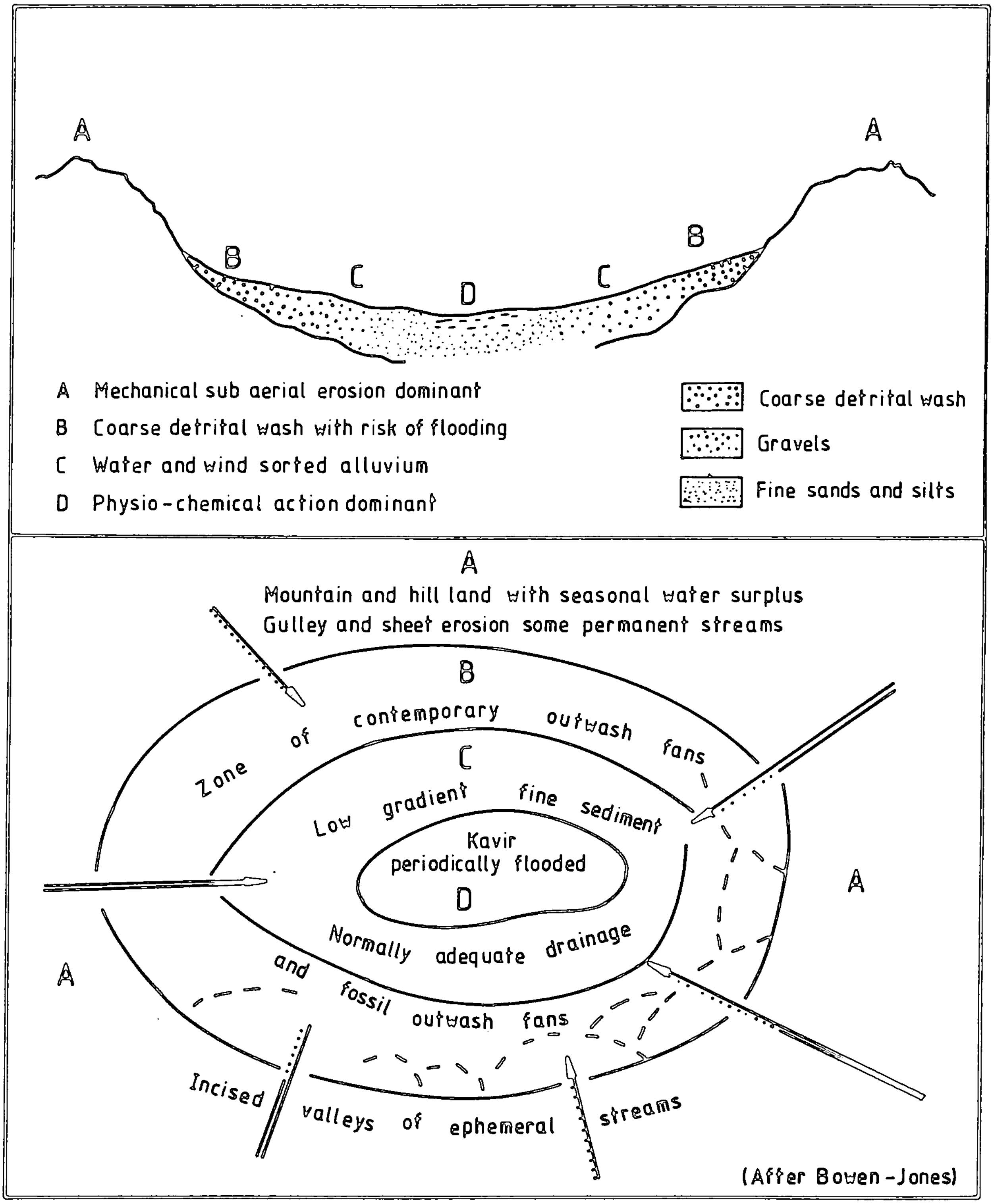


Figure 3.12 Schematic plan and cross-section of an endoreic basin (after Bowen-Jones, 1968).

mainly coarse-grained, being either large boulders near the mountain foothills, or gravel, sand and silt at the junction of the fans with the Kavir (Zone C). As the material is course grained it is therefore highly aquiferous and is a great source of surface water which descends from the solid beds of mountains on to the fans by percolation. In fact the estimated annual natural recharge in this part of Khorasan (around 1300 million m^3) is mainly dependent on the floods from the mountains spreading over the alluvial fans and percolating here.

ZONE C: This is a zone of the alluvial plain situated between the course detrital wash zone of alluvial fans and the periodically flooded zone of the Kavir (Figure 3.12). The material involved in the deposition, although principally the same as in Zone B, can be clearly distinguished by its fineness and in containing a higher percentage of clay and small gravel. As a result of this, alluvial material in this zone is much less permeable than that of Zone B. However, it should be pointed out that the reduced amount of water percolation here is not only because of the character of the alluvium, but also because of the absence of surface water and the reduced precipitation.

An additional problem of groundwater resources in this zone is that in large areas the alluvium is underlined by Pliocene-miocene formations (Figure 3.11), which contain thick beds of evaporites. These formations are predominantly made up of gypsum, salt and sandstone and thus resulting in highly saline and poor quality groundwater resources. Moreover, due to the proximity of the water table to the land surface, evaporation through the capillary action brings about a gradual increase in the salt content of the water. This process of salinization is increased by the percolation of irrigation water (Issar, 1969).

ZONE D: This zone includes the flat sandy desert areas of the central basins. The sediment here is mainly sand, clay and silt. The percentage of clay and sands is generally higher than in the previously mentioned zones. The surface sands are easily removed by the winds and are usually redeposited in the form of sand dunes. Although the sands are highly permeable its effect on the groundwater is negligable due to the shortage of rainfall and surface runoff in the area.

Among the four zone areas Zone A (upland areas) is occupied by nearly one third of the villages (845 or 31 per cent of the total). They are scattered and found where the necessary conditions for water supply and flat land can be fulfilled. In the lowland areas, the most densely settled areas and most prosperous villages are found in Zone B (on alluvial fans), and upper areas of Zone C where better quality groundwater can be obtained. The significance of settlement in the lower parts of the basins is slight. Villages became generally more scattered and smaller towards the centre of basins, and due to absence of surface water, shortage of rainfall and salinity of the soils the villages here are small, isolated, and more dependent on fresh water transferred from the mountain foothills by qanats.

Southern Khorasan: As can be seen from Figure 3.11 it is only in small areas of the mountains of southern Khorasan (Qaen, Gonabad and a small area to the east of Birjand), that highly permeable Cretaceous limestone is found. The remaining upland areas are dominated by Tertiary volcanic rocks which cover a large area of the region from Gonabad to as far as Safidabeh, (200 km south of Birjand). A characteristic of these rocks is that they are impervious and thus have no positive effect on the development of groundwater reservoirs.

In the lowland areas, although the course grain materials on the fans are highly permeable, due to a shortage of rainfall and surface water the recharge is poor. Away from the fans and towards the Kavirs surrounding the highlands the quality of groundwater is more saline due to the wide-spread Tertiary gypsiferous and soliferous Miocene marls and Pliocene conglomerate.

In general, it can be said that due to the impervious nature of the rocks and the shortage of rainfall in lowland areas the value of recharge in the area is negligible. The total approximate recharge volume is approximately 360 million m^3, which is only 12 per cent of the total in the province, but while occupying 54.2 per cent of the total land area. As a result, villages in this part of Khorasan are very small. Their average size, particularly in lowland areas, is far below that of the province average (being 168 against an average 286 persons). They are also much more widely spaced, the distance being nearly three times greater than the provincial average.(see Chapter 6).

Having looked at some of the physical components of Khorasan and identified clearly the relationship between settlement patterns and water supply, it is important to examine the regional variations of water availability in more detail. This is done in the next two chapters which examine surface water and groundwater respectively.

CHAPTER 4 : SURFACE WATER SUPPLIES

DRAINAGE SYSTEMS

The Khorasan region can be divided into five major drainage systems. These are Caspian drainage, Qarehqum, Dasht-e-Kavir, Dasht-e-lut, and Eastern marshland drainage systems (Figure 4.1).

i) Caspian drainage - The Atrak is the sub drainage system in Khorasan which flows into the Caspian Sea. The Atrak basin includes almost the entire north western part of Khorasan and the river flows in a narrow valley between the two mountain ranges of Culul-Dagh and Allah Akbar in the north, and Aladagh and Shah Jahan in the south. This zone has approximately 300 to 500 mm of precipitation per annum, the highest in Khorasan. Thus the upland valleys are well supplied by streams and springs, and are generally regarded as the most reliable in the region. The Atrak itself begins its course at Ghofranlu, 28 km east of Quchan, at the confluence of the Sevzeh and Zirabad rivers. The river flows westwards for approximately 535 km and after passing through the fertile intermontane plains of Quchan, Shirvan, and Bojnurd it finally drains into the Caspian. During its journey the Atrak is fed by numerous rivers which descend from the surrounding upland areas. The most important of these tributaries are the rivers Qoljoq, and Shirin Dareh from the northern ranges and the Goliyan, Shahjuy, Badranlu and Samalqhan (See Figure 4.1). from the southern ranges.

ii) Qarehqum drainage* - In Khorasan this drainage network is comprised mainly of the Dorungar, Kashaf, Harri Rud and Tajan rivers. It

* also spelt as Qara Qum

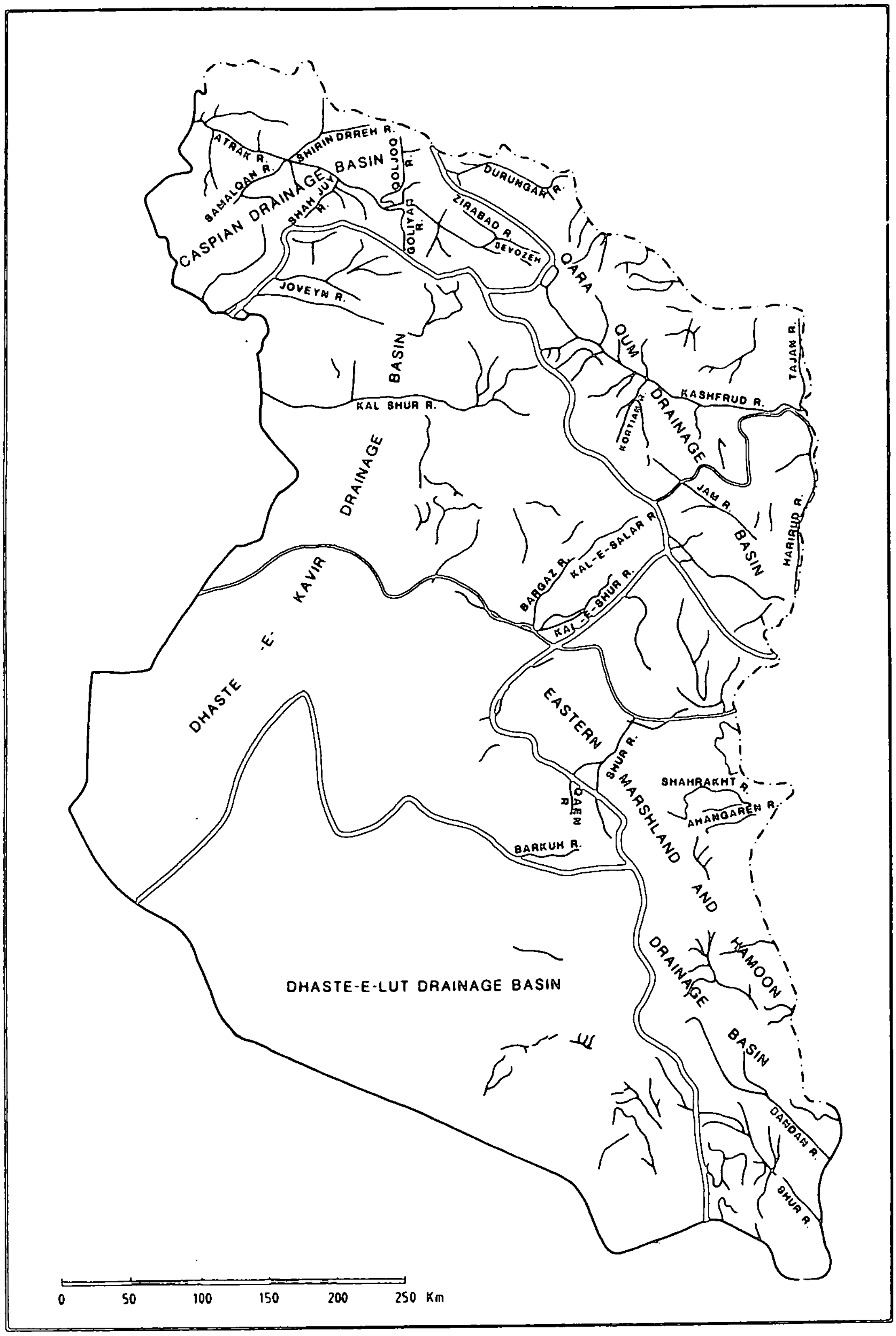


Figure 4.1 Principal drainage basins of Khorasan.

has already been shown (Chapter Three) that annual precipitation falls to 200-300 mm per annum east of Quchan and over the areas of north eastern Khorasan. Thus the drainage of this area carries less water than the Atrak. Of the rivers mentioned above the Kashaf is the most important one; its entire 16,526 km² drainage is situated within the region of Khorasan, between the mountain ranges of Hezar Masjed in the north and Binalud in the South. The river Kashaf originates in the eastern hills of Quchan and after flowing eastwards for about 300 km during which it is fed by its main tributaries - notably the Kardeh, Toroq, Torqabeh, Golmakan and Akhlamad, it finally meets the river Tajan at Pol-e-Khatun to form the Harri Rud (Figure 4.1). This latter river forms part of the border between Afghanistan and the USSR, whilst the Tajan, which drains into the Qarehqum within Russian Territory, forms the Iran/USSR boundary north of Pol-e-Khatun.

iii) Dasht-e-Kavir Drainage - The main rivers of the Dasht-e-Kavir drainage system are the Kal Shur and the Bar. The former originates at Kuh-e-Qareh Kamar and has a drainage area of approximately 111 km². It passes through the basins of Neyshabur and Sabzevar and finally after a westerly flow of 223 km it drains into the Dasht-e-Kavir depression. The Kal Shur river acts as a sub-drainage system for a number of intermittent streams which flow from the Kuh-e-Binalud and Kuh-e-Surkh. The most important of these is the Bar which originates from the southern flanks of Binalud descending southward over the Neyshabur plain and drains into the Kal Shur river (Figure 4.1).

iv) Dasht-e-Lut Drainage - The main rivers of this drainage network within the region of Khorasan are the Kal-e-Salar, Shast-Dareh and Sheshtraz. These all originate from the southern flanks of Kuh-e-Surkh, descend into the immediate foothill plains of Torbat-e-Heydariyeh and Kashmar, and finally disappear in Kavir-e-Namak and Shahdad (Figure 4.1).

v) Eastern marshland drainage - This drainage system lies at a relatively lower altitude than the other networks of Khorasan region. It is located in the east of the region, almost parallel with the Afghanistan border. There is no dominant stream within this drainage system. The surrounding upland watersheds are dry for most of the year and it is only during the wet season (winter and spring) that the upland rivers manage to have some runoff to form the lakes and marshland areas in the Afghanistan border area. The most important of these rivers are Fadak, Shah Rukht, Rud Shur, Farrokhi, and Rud-e-Kal (Figure 4.1).

Of the five major drainage systems of Khorasan identified above the Dasht-e-Kavir, Dasht-e-Lut, and the eastern marshland drainage are located in very arid areas. They are the most arid drainage systems of Iran, caused by precipitation which rarely exceeds 200 mm per annum (Chapter Three).

HYDROLOGICAL CHARACTERISTICS

The rivers of Khorasan have the following major characteristics :

i) Low discharge - The discharge of the rivers of Khorasan is generally very low compared with other rivers of Iran. This can be illustrated with the following example. The total average annual discharge of the thirteen largest rivers of Khorasan is only about

550 million m³ (Table 4.1). That is approximately more than two times smaller than the river Zayandeh-Rud in Esfahan (1128 million m³ measured at Qaleh Shah Rokh Station) and seven times smaller than the river Karun at Ahvaz (3,776 million m³ measured at Armand Station).

Relief and precipitation dictates the levels of discharge of the rivers within the Khorasan region; there is a general decrease from north to south. Higher relief and heavier rainfall leads to relatively higher discharge for rivers in the north of the region, whereas towards the centre and the south decreasing altitudes and precipitation leads to much lower river discharges. This point is demonstrated in Table 4.1. The total discharge of the three largest rivers of central Khorasan, namely the Bar, Kal Shur and Shast-Dareh is only 42.4 per cent of the average annual discharge of the Chanaran a tributary of the river Atrak in the north which has an annual discharge of 100 million m³.

ii) Marked annual variations in discharge - because of extreme fluctuations in annual precipitation, the discharges of the rivers of Khorasan vary markedly from one year to another. Figure 4.2 shows that in two successive years (1968 and 1969), the annual discharge of the Kashaf Rud ranged from 197.6 million m³ (274.5 per cent of the average 1951 - 70) in 1968 to as low as 6.9 million m³ (only 9.5 per cent of the mentioned annual average for 1951-70 period) in 1969. This example of marked annual fluctuation in the Kashaf is representative of other rivers in the region. In Tajan, for example, the amount of annual discharge in 1951 was 11.3 times greater than that of 1965 (see Figure 4.3), and in the case of the river Taragh, one of the

Table 4.1 Surface water discharge of major rivers (1952 to 1971)

River	Average annual discharge in million m
Tabarik	38
Qoljoq	44.2
Chanaran	100
Samalqan	70
Shirin Dareh	72
Dorungar	33
Kashaf Rud	72
Toroq	17
Kardeh	40.6
Fariman	21.4
Average North	50.8
Bar	22
Kal-e-Shur	1.9
Shast Dareh	18.5
Average Central	14.1
Average South	0
Khorasan	42.3

Source :Plan Organization (1972b)

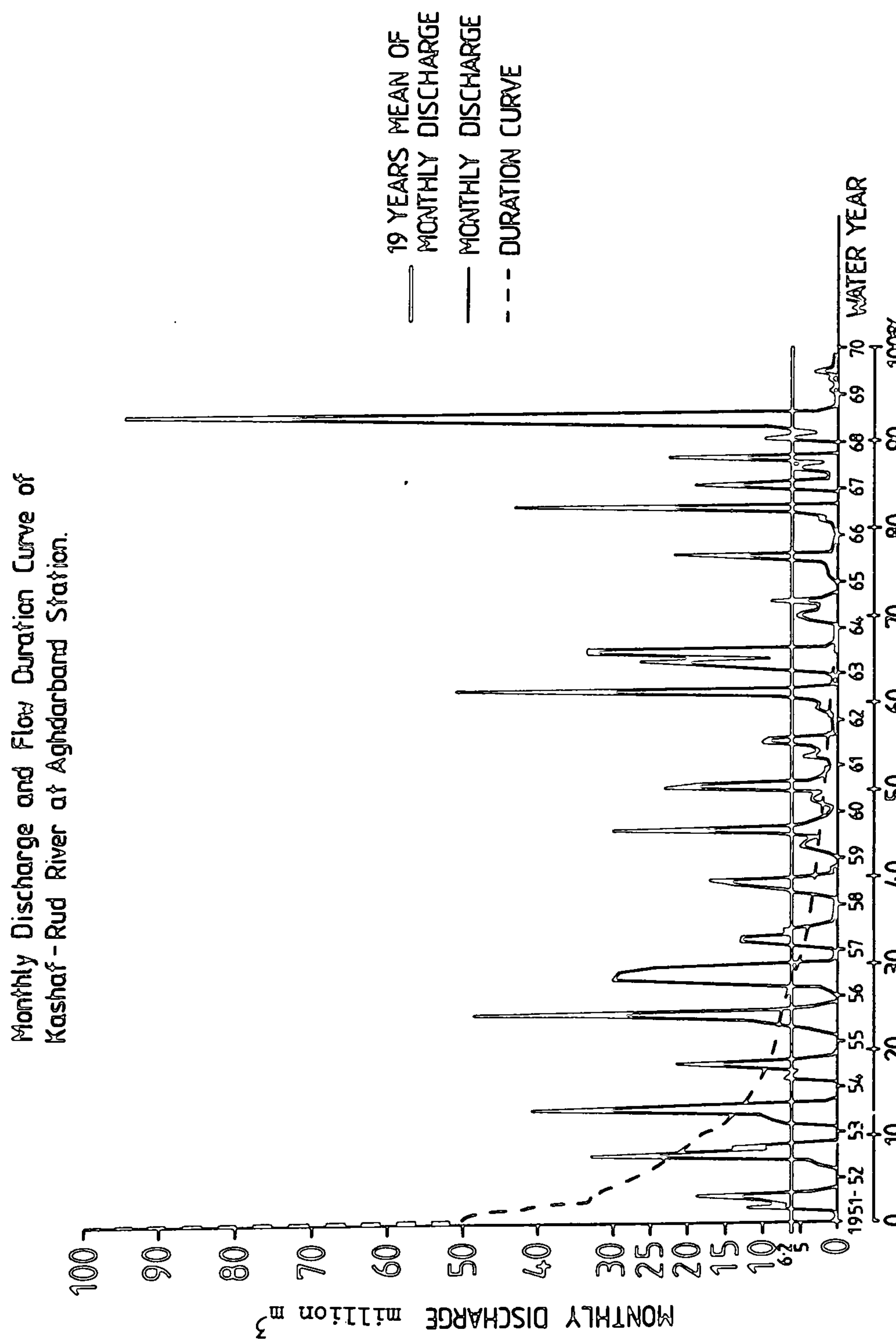


Figure 4.2 Monthly discharge and flow duration curve of
Kashaf-Rud River at Aghdarband Station.

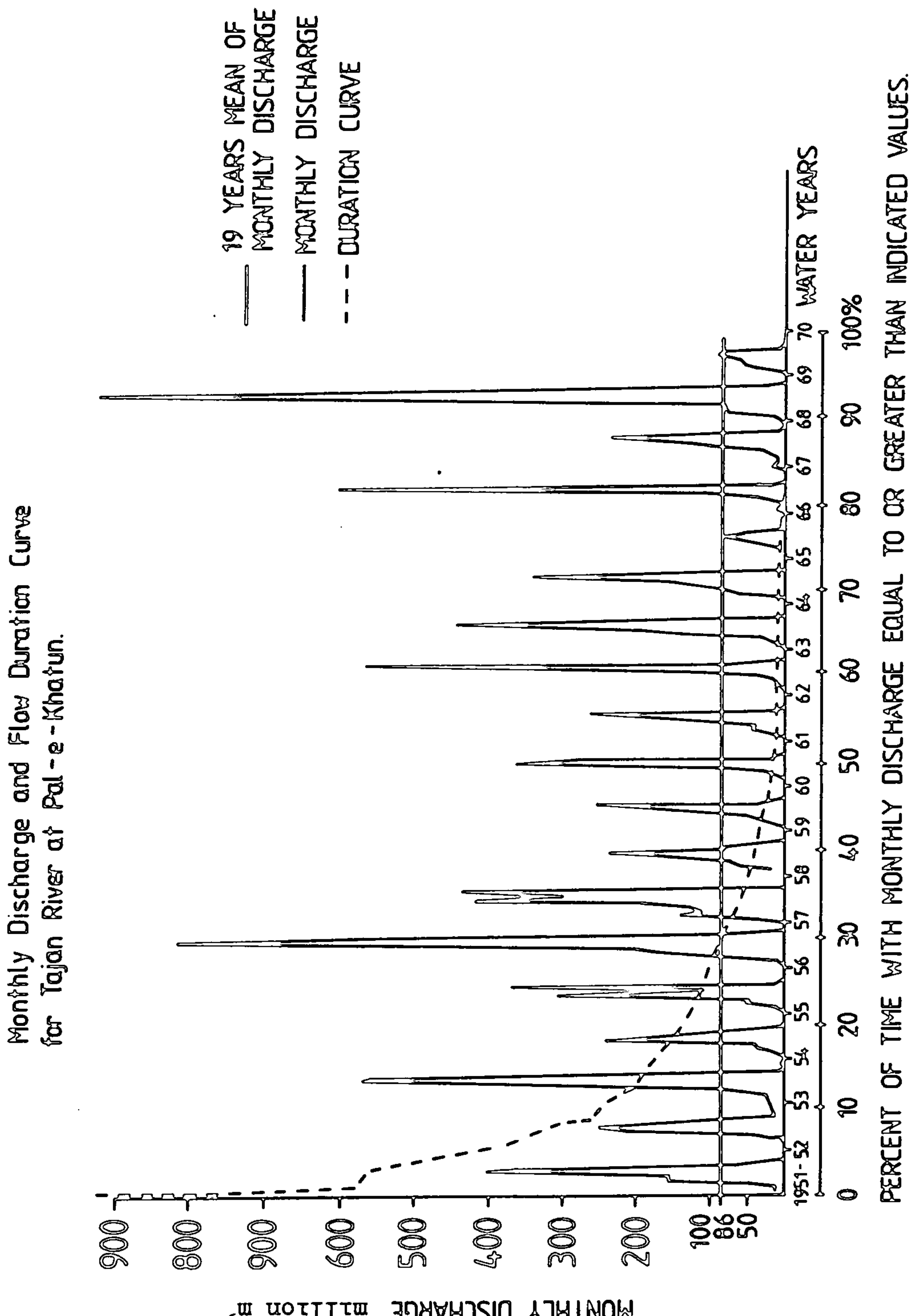


Figure 4.3 Monthly discharge and flow duration curve for Tajan River at Pal-e-Khatun.

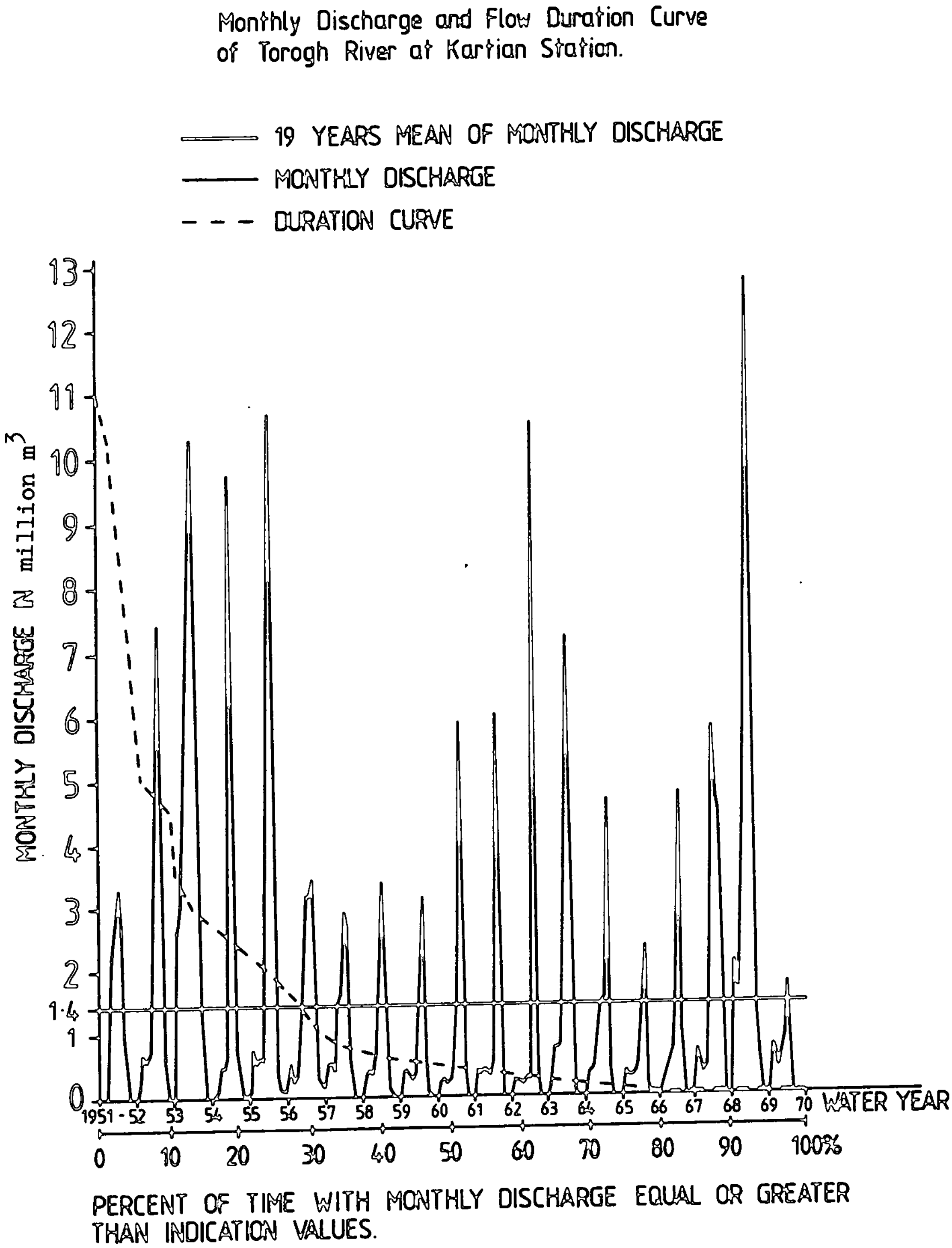


Figure 4.4 (title as above).

tributaries of the Kashaf, the annual discharge between the period of measurement (1951-70) varied from 48.5 million m^3 in 1953 to 5.7 million m^3 in 1969 (Figure 4.4).

iii) Marked seasonal variation in discharge - Another characteristic of the rivers of Khorasan is that their regimes are extremely seasonal. Whenever there is a combination of high precipitation and snow melt in the high altitudes (as for example in early spring - March and April) the rivers usually overflow and flood, whilst in the summer, due to little precipitation and no snow melt, many streams dry out completely. Data for the Kashaf-Rud (Figure 4.2) shows that for only 28 per cent of the year does the discharge exceed the average monthly figure of 6.2 million m^3, whilst for almost three months of the year the river is dry. The average monthly discharge for the river Tajan during the year between 1951 and 1970 was 86 million m^3. Figure 4.3 shows that for only about 29 per cent of the year (104 days) was the discharge greater than the average, and for about four months of the year the river is usually dry. A similar pattern can be seen for the river Torogh (Figure 4.4).

iv) High level of salinity - As stated previously many of the soils of the Khorasan region suffer from salinity, especially those at lower altitudes. As a result, rivers increase in salinity the further they are from their origins in the upland areas. In some of their lower reaches, for example, in the Kashaf and Kal Shur rivers salinity is sufficiently high to make the water useless for agricultural purposes.

UTILIZATION OF SURFACE WATER

An average annual precipitation of at least 300mm is normally required for dry farming. It has already been shown in the previous chapter that this amount of precipitation is restricted to limited areas of Khorasan, mainly around Bojnurd in the extreme northwest and marginal areas at high altitudes. The remaining part of the region, the vast majority, has therefore to rely on irrigation for agriculture. Surface water is utilized for irrigation by constructing canals, barrages and dams.

Canals: the surface water of Khorasan has traditionally been utilized for irrigation by means of canals diverting river water to favourable agricultural areas. The length and the importance of these canals is usually determined by topographical factors combined with the reliability and availability of the river source. Good example of the use of canals can be seen along more reliable rivers such as the Tabarik, Qaljoq and Tajan. From the river Tabarik nineteen canals bring a total of approximately 1,000 ha of land near the village of Tabarik under agriculture and twelve other neighbouring villages are also irrigated. There is also a number of smaller canals which transfer water from the river Qaljoq to the nearby villages of Qaljoq, Firuzeh, Hasar-e-Musaback, Mohammad Ali Khan, Zirab and Mansuran. However, the most important surface canals of Khorasan divert about 30 per cent of the river Tajan to nearby cultivated areas. The most important of these canals are the Mozaffari, Sangar and Dowlat Abad. The Mozafari Canal is about 18 km south of Sarakhs; it has a length of 70 km and has the capacity to carry 7.5 million m^3 of water per second. Water from this canal is used mainly for irrigating lands around the villages of

Mozaffar and Dowlat Abad. The Sangar water canal is about 30 km south of Sarakhs, and has a maximum capacity of 520 litres per second. The Dowlat Abad water canal is about 25 km south of Sarakhs. It has a maximum capacity of about 1400 litres per second and is capable of irrigating 1,000 ha of cultivated land around the village of Dowlat Abad (Ministry of Water Supply, 1972)

Water divided from a river may serve more than one village. In this case water is shared according to local agreement. A good example of such a case is given by Flower (1966) who also described the technique for diverting river water and its distribution (See also Figure 4.5).

"The water was diverted along channel A when needed, by means of a small mud dam across the river until it reached the concrete device at letter B (see inset for enlargement). Then, as the water served two villages, one seventh went to Morghanan (with a population of 150 to 200) and the remaining six sevenths went to Cenabis (population of 6,000). If water was wanted for irrigation then the villagers merely went to the river, the Kashaf Rud, and diverted some of the flow. The concrete barrier was to prevent a constant flow of water up the irrigation channels but when the water was diverted up the main channel A it easily overlapped the concrete block B which acted as a kind of water storing device."

Barrages and Dams: the construction of barrages and small dams is another way of utilizing surface water in Khorasan. One can see many examples of constructed barrages in different parts of the region such as at Akhlamad, Golestan, Toroq and Fariman near Mashhad; Kelar and

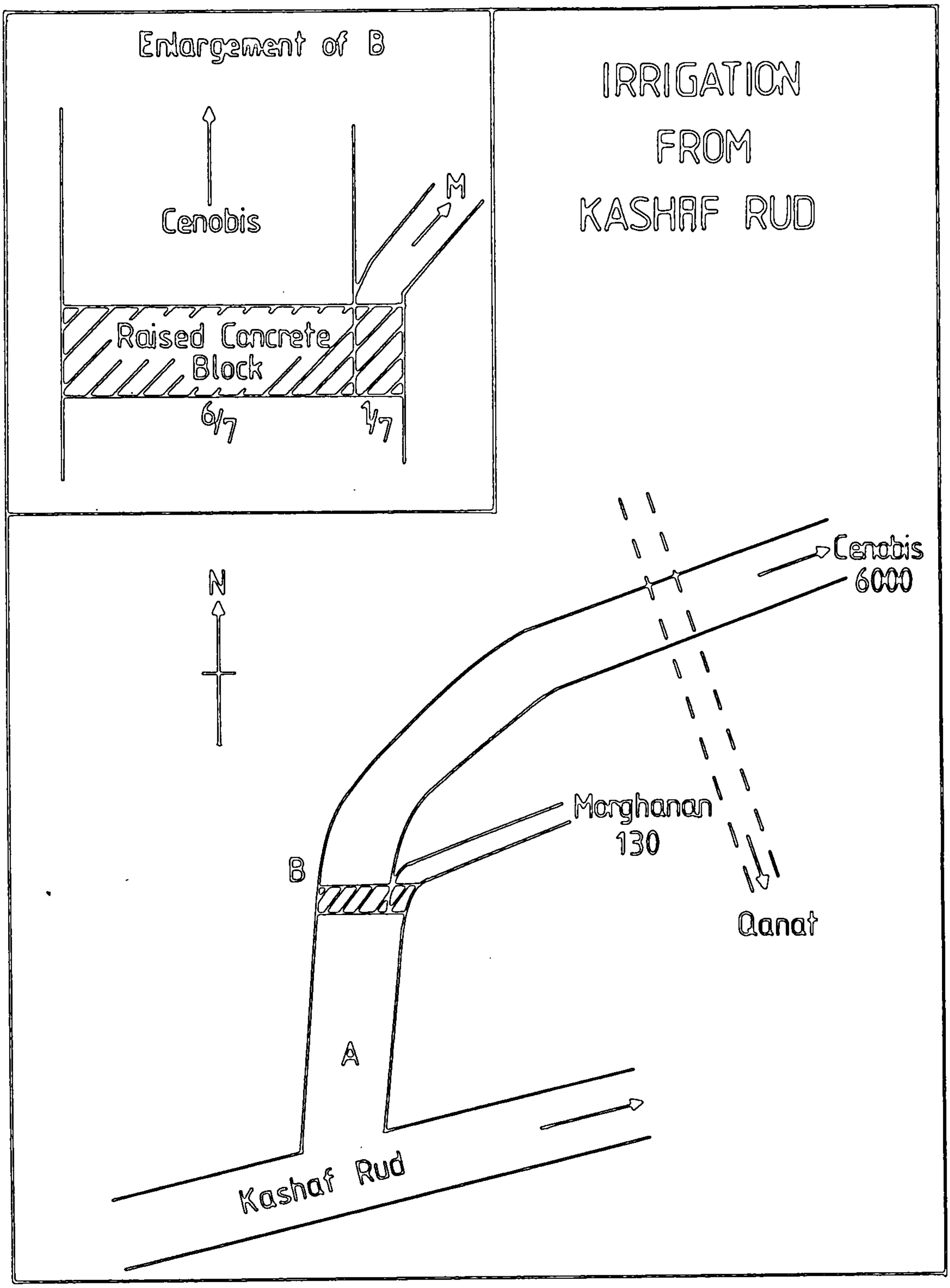


Figure 4.5 Irrigation from the Kashaf Rud (after Flower, 1966)

Filband in Torbat-e-jam; Karat, Polband and Salami in Torbat-e-Heydariyeh; Karit in Tabas, and Dareh and Omar Shah in the Birjand area. Traditionally all of these barrages were built across river valleys to collect and store the Spring flood water for the Summer when it is most needed. However, at the present time most of these traditional devices are abandoned or in a state of ruin. They are generally filled up during the course of time with mud and other materials brought by the seasonal floods. Those which are still being used and have some contribution to local irrigation are at Golestan, Toroq and Fariman. They have a total water storage capacity of about 10 million m^3, and are used for irrigation for nearby cultivated areas.

Unlike, some other regions of Iran which have well developed river networks, such as Karun in Khuzestan, Zayandeh-Rud in Esfahan and Safid-Rud in Gillan, the construction of large storage dams is not economical in Khorasan. This is due to low volume discharge, together with marked annual and seasonal fluctuations. Nevertheless, in the early 1970s the construction of two small modern storage dams near Mashhad was recommended. This was partly due to a continuing rapid increase in population (and thus water demand in Mashhad) and partly because further exploitation of groundwater for the city resulted in a drop in the level of the water table, sometimes by more than twelve metres (Ministry of Water Supply, 1972) (see also Chapter 5). The construction of these two dams, one on the river Kardeh (about 38 km north of Mashhad) and the other on the river Toroq (about 16 km south east of Mashhad) is complete and although the aim of construction was mainly to increase water shortage for the regional capital Mashhad, they were also utilized to add about 2,800 ha of land to irrigation (Plan Organization, 1972b)

PROBLEMS OF SURFACE WATER IRRIGATION

One of the main problems of surface water irrigation in Khorasan is the geographical distribution of its rivers, which have been shown to vary according to the patterns of relief and precipitation. Therefore the best supplied rivers of Khorasan are restricted to small areas in the north, whilst the vast majority of the region is situated within the poor drainage systems of the Dasht-e-Kavir, Dasht-e-Lut and the eastern marshland along the Afghanistan border. Except during floods, there is hardly any surface water at all in the central basin areas.

The highly erratic and seasonal regimes of the rivers of Khorasan means that the utilization of water for irrigation can have serious effects on total discharge. This can make irrigation in the lower parts of the rivers unreliable and risky. The unreliability of irrigation increases the importance of rules for the allocation of river water for farming. Traditionally, the village closest to the source of a river has a right to take as much water as it requires, and villages downstream have to be content with what is left over. For example, the village of Toroq, which is situated on the lower reaches of the river Toroq (approximately 7 km south of Mashhad) will take water after the villages situated upstream, namely Moghan, Khanrud and Ardameh. This is because there is no division into shares and disputes over water between the villages are common.

Another major problem with surface irrigation is that a great deal of water is lost through high rates of evaporation, poor maintenance of the canals and high permeability of the soils. According to the Ministry of Water Supply, the average loss of water for the canals of Khorasan with a discharge greater than 25 litres per second is 8 to 10 per cent per km, and for those with a discharge between 12 to 17 litres per cent the loss of water is estimated to be between 10 to 20 per cent per km. Naturally, long canals lose more water then short ones.

For the reasons discussed above, it can be generally stated that the surface water of Khorasan is not a reliable source for irrigation and, despite the cost of building canals , many of the villages utilizing the river source have to rely on alternative irrigation techniques such as qanats and wells.

THE EFFECT OF SURFACE WATER ON SETTLEMENT PATTERNS AND SIZE

By comparing the distribution of rivers and settlements relying on river water for their existence (Figures 4.6, 4.9 and 4.10), it is clear that a relationship exists but the distribution of villages is not regular. Of the total 1,101 villages of Khorasan using rivers as a source of water in 1966, 719 or 65.3 per cent were located within the northern drainage zones of the Atrak and Kashaf, where as discussed earlier, the availability and reliability of the river water is greatest, and, with the exception of rocky areas on the northern bank of the river Atrak in Bojnurd, and the saline riverain areas of Kashaf further to the east of Mashhad, the remaining riverain areas of these two major rivers of Khorasan are generally on good agricultural land and exhibit no or only slight limitation for the cultivation of the most important crops of the area : wheat, barley and sugar beet. It is for the same reasons that in this part of Khorasan settlements using the river source are greater in number and more densely distributed along and in close proximity to the upper riverain areas of the Atrak and

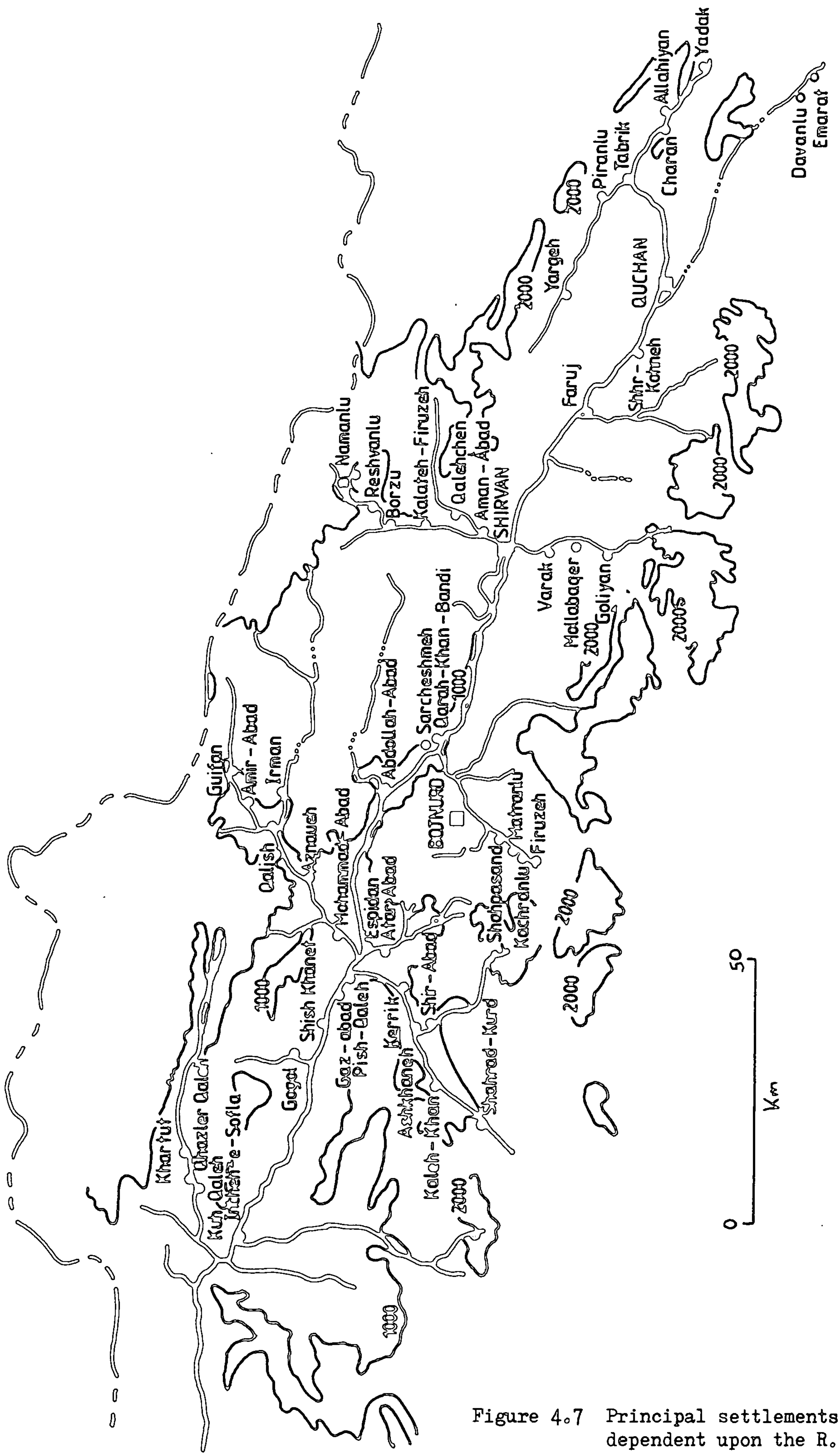


Figure 4.7 Principal settlements dependent upon the R. Atrak.

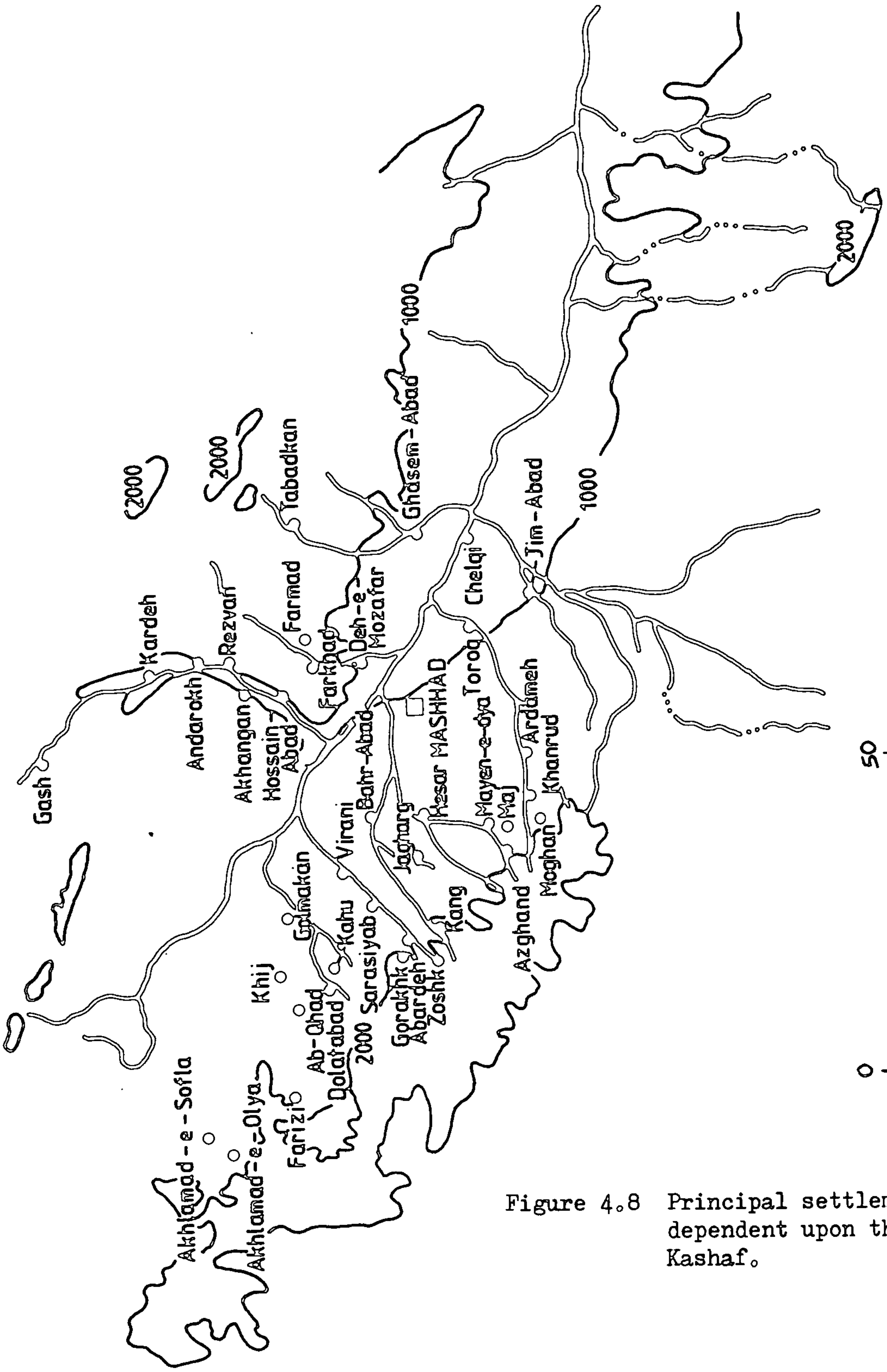


Figure 4.8 Principal settlements dependent upon the R. Kashaf.

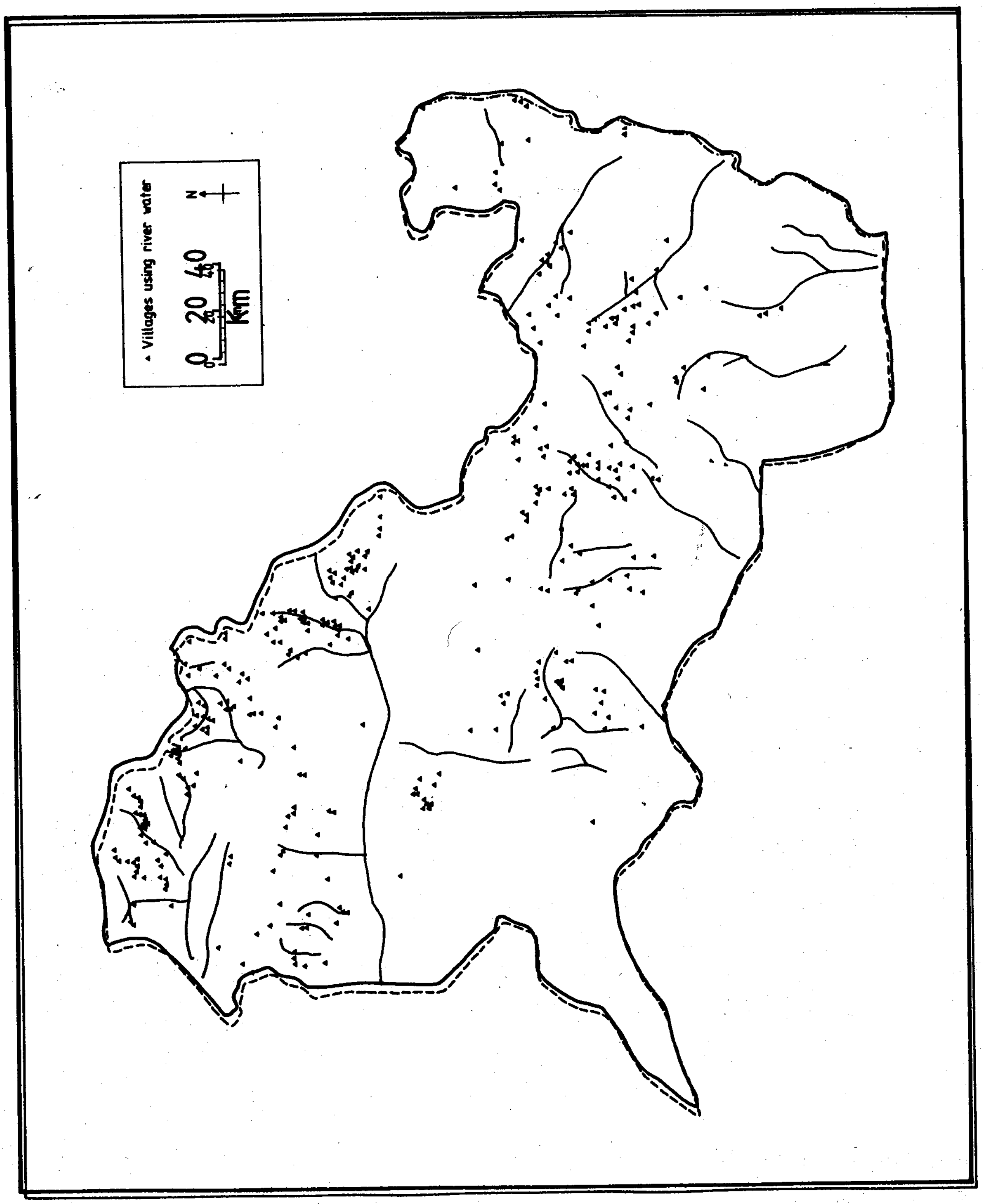


Figure 4.9 Villages of the centre which rely on surface water (with drainage overlay).

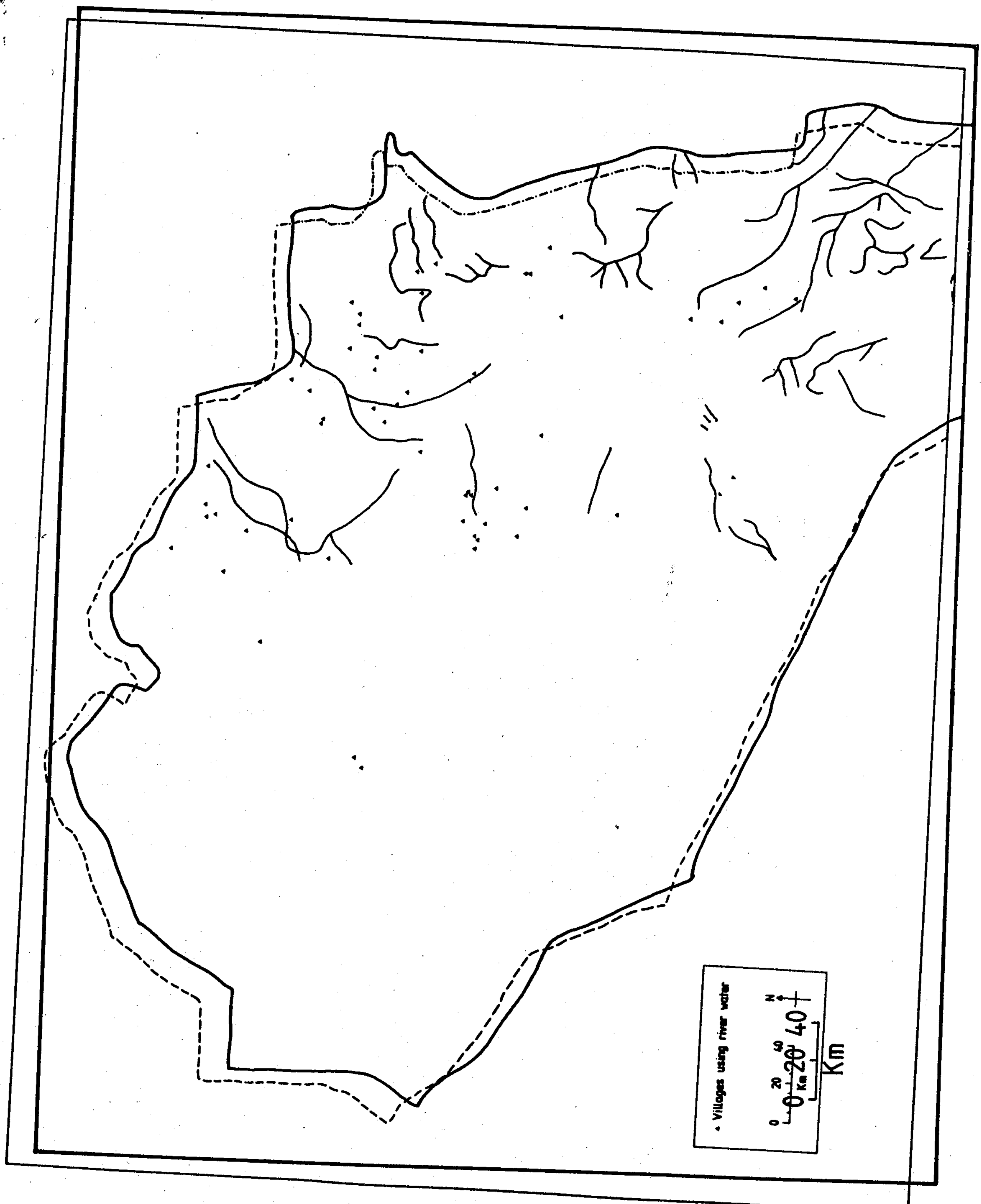


Figure 4.10 Villages of the south which rely on surface water (with drainage overlay).

Kashaf (see Figure 4.6). Many of the other villages in the area using river source are located with reference to upland rivers and the major tributaries of the Atrak and Kashaf, particularly those originating from the southern ranges of Binalud, and Shahjahan. Despite the fact that surface water is more easily obtainable in upland areas, the villages here are generally smaller than in the lowland areas. This is partly because of the topography which often limits cultivation and partly due to the fact that upland areas are generally less suited to other forms of irrigation such as qanats and wells. A greater concentration of large upland villages in the northern areas of Khorasan is found in the narrow and deep upland river valleys formed along the northern flanks of Binalud, south west of Mashhad. These villages are Kang (population 2,196 according to the 1976 village gazetteer), Zoshk (2,849), Abardeh-e-Olya (2,688), Golmakan (4,523), Hassar (1,181), Gorakhk (1,055) and Akhlamad (1,325). They are important for fruit production, and are well suited to the upland environment. Figures 4.7 and 4.8 show the distribution of some of the largest villages using the river source of water from major tributaries of Atrak and Kashaf.

A characteristic of the poor drainage systems of the central areas of Khorasan is that there is a shortage of reliable surface water and fertile agricultural lands, the best areas being restricted to the upper parts of the basins. Hardly any surface water reaches the central basin areas, as most of it either infiltrates into the alluvial fans, or is used in the upper parts for agricultural purposes. The only time when water is normally found on the surface of the central basins is in the Spring when convectional rainfall is supplemented by snowmelt. As a result, the largest and most densely settled areas of the villages of central Khorasan are found in the upper parts of the basins. Towards the centre of the basins, as the quality and quantity of the river water decreases, the villages become more scattered. Among the rivers of central Khorasan Kal shur, Bar, and Shast Dareh have the largest concentration of villages along their upper riverain courses. (Figure 4.9).

In the southern areas of Khorasan there are few rivers and only a few villages can exploit surface river water. Those villages which do exist are very unevenly distributed over the area (see Figure 4.10). Most of the area is in fact desert but there are a few small villages using the river source, concentrated in the highland areas to the east of the region, mainly around the Birjand and Qaen highlands.

CHAPTER 5 : GROUNDWATER SUPPLIES

INTRODUCTION

Despite the marked aridity of the region of Khorasan a large concentration of densely populated villages are found. For these settlements to exist in such arid conditions, it has been necessary to supplement the low rainfall by utilizing groundwater resources which (as discussed in Chapter 3) are facilitated by the special geological conditions prevailing in the region.

The following study of groundwater utilization will refer firstly to the main methods of groundwater utilization (qanats, wells and springs), and their particular impact on the characteristics of irrigation and settlement in the region, and secondly will examine the groundwater resources in relation to water quality, potentiality and consumption. The study is mainly based on the information given by the Village Gazetteer of Khorasan Province (1966 and 1976), Statistical Year Books and available hydrological reports. However, it is important to note that the available data concerning the groundwater resources of Khorasan region are still far from being comprehensive. An investigation of the spatial distribution of groundwater resources (Figure 5.1) suggests that it is only in limited areas of Khorasan, namely Mashhad, Neyshabur and Sarakhs plains, that detailed investigations have been completed, although even in these areas there are considerable data imperfections. In Quchan, Bojnurd and Kashmar investigation of groundwater resources is still in progress. In the vast remaining areas of the Province, including Dargaz, Sabzevar, Torbat-e-Jam, Torbat-e-Heydariyeh, Gonabad, Ferdows, Qaen, Tabas, and

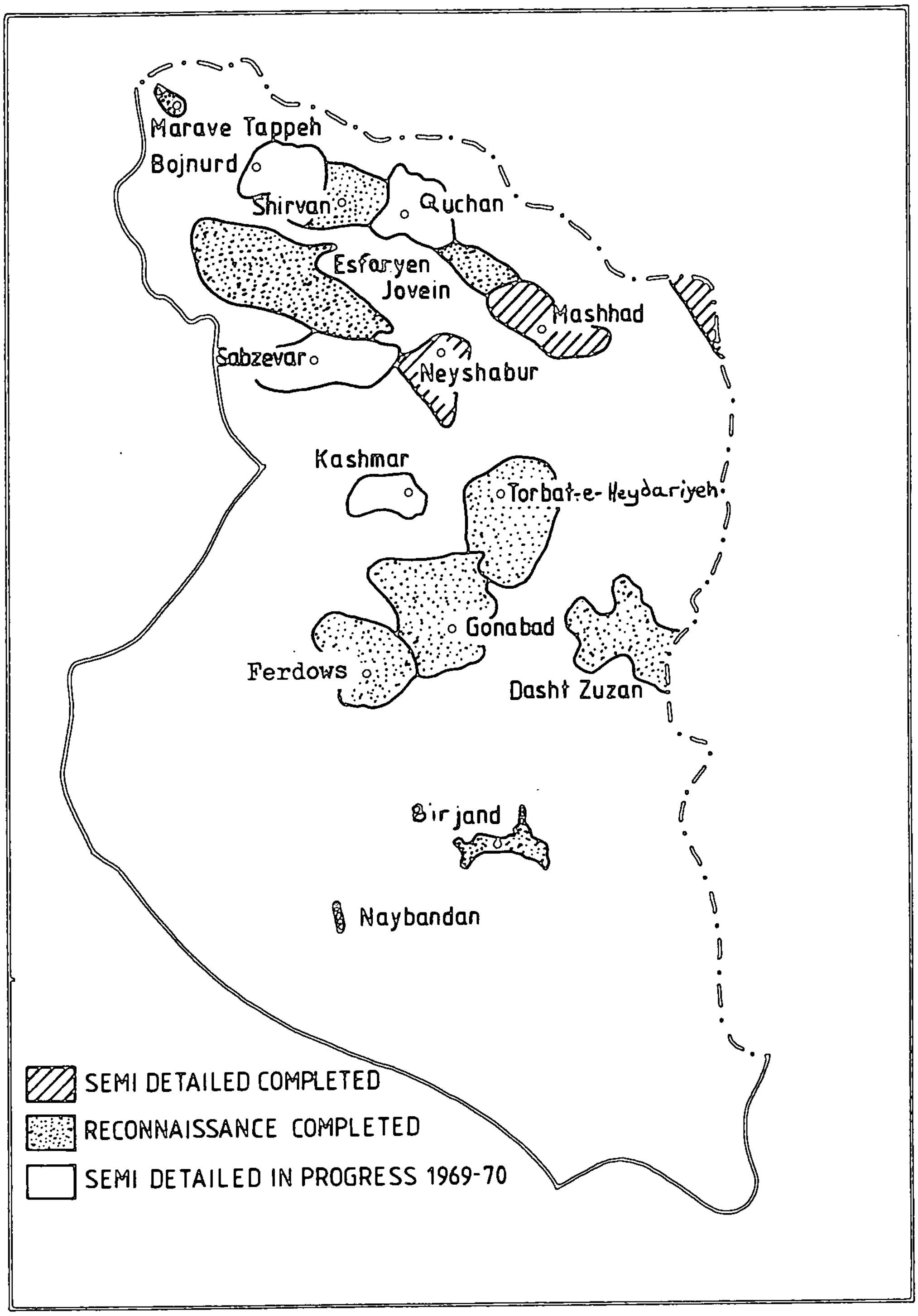


Figure 5.1 Distribution of groundwater resources.
(based on United Nations, 1971).

Birjand, the investigation of groundwater resources is still in a reconnaissance stage. Nevertheless, available materials such as the hydrological reports (Ministry of Water Resources), and the more detailed studies available from some areas (particularly Mashhad) presents a general picture of the groundwater resources in the area.

As in many other regions of Iran, there are three major methods for the utilization of groundwater reservoirs in Khorasan : (i) qanats, (ii) wells and (iii) springs. Each of these methods has its own impact on irrigation and settlement, thus they are studied individually in the first instance and then in a later section their effect as a whole is examined.

QANATS

Since pre-Islamic times groundwater has been utilized in Khorasan by the technique of qanats. For example, the presence of qanats in Mashhad, Sabzevar and Gonabad is recorded as far back as the Hakhamanishid period 550-330 BC (Ministry of Water Supply and Power 1969).

General characteristics and construction : A qanat is an underground tunnel constructed through alluvial material which transmits water by gravity from beneath the water table to the ground surface (Figure 5.2). As shown, there are two sections recognizable in a qanat. First, the 'wet section' which is in fact the water producing section, that is the part into which groundwater drains. The second section is the 'dry section' which acts as the transportation part of the qanat. Whereas the 'wet section' is only a few tens of metres long, the dry section may

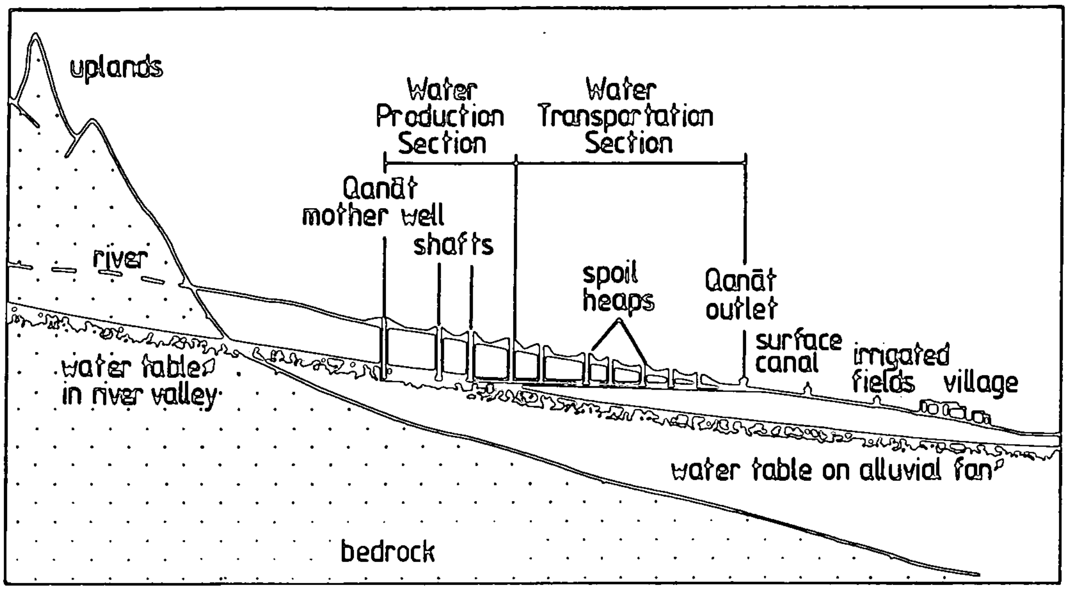


Figure 5.2a A typical qanat (based on Beaumont, Blake and Wagstaff, 1977).

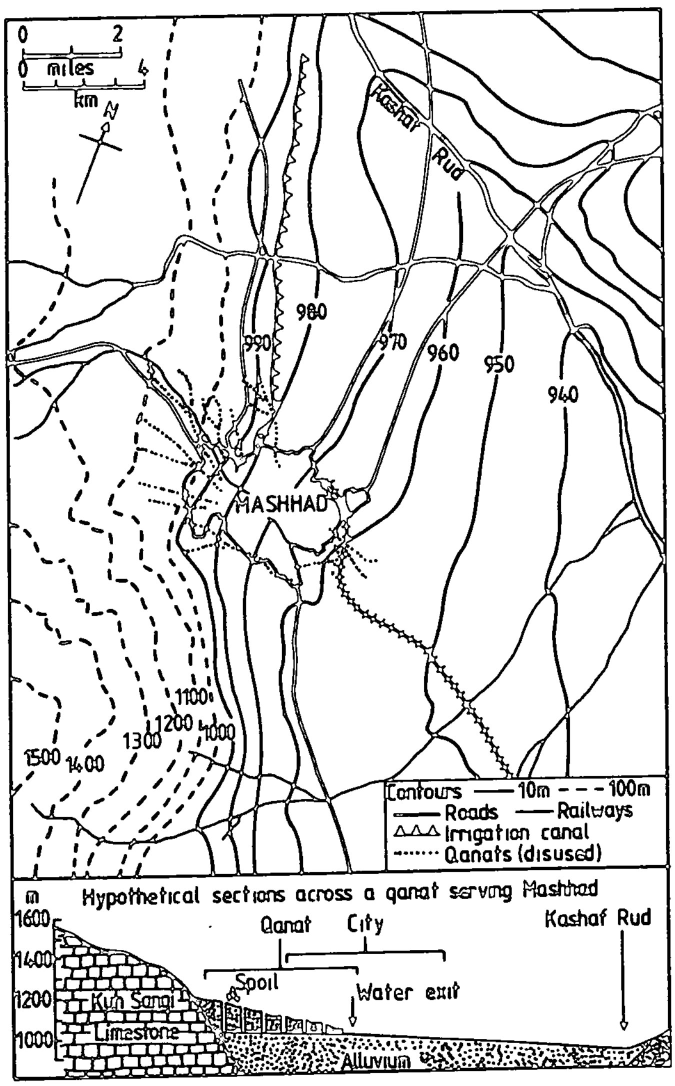


Figure 5.2b Simplified qanat system around Mashhad (based on Fisher, 1968).

extend over several kilometres. In Kerman, one of Iran's most arid regions qanats extend more than fifty kilometres southwards to penetrate the water at the base of Japur mountain (Golabian, 1977). In Khorasan, however, qanats with a length of over twenty kilometres are frequently recorded. In one example Tahghighat-e-Eghtesadi (1969) refers to a qanat thirty kilometres in length, serving the two villages of Dohesaran and Behgard in the Ferdows area.

For a qanat to be constructed, first a mother well is dug at the upslope end to determine the depth to the water table and the sub-surface sedimentary material. Then the tunnel construction starts in an upslope direction from the selected outlet. To provide ventilation for the workers in the tunnel and to facilitate the removal of soil a series of vertical shafts are dug along the line of the tunnel at a selected distance. The tunnel must have a gentle slope to prevent erosion and collapse. In areas of weakly formed sediments baked clay rings are used to avoid roof and wall collapse.

The length of qanats varies considerably, depending on the slope of the ground surface, and the depth and inclination of the water table. Short distance qanats (only a few hundred metres long) are found mainly at the foot of mountains where the steep slope of alluvial deposits is more marked. By contrast the longer qanats are found where ground slopes are minimal.

An investigation of qanat length in three areas of Khorasan, Mashhad in the north, Sabzevar in the centre and Gonabad in the south suggests that the length of qanats generally tends to increase towards the south of Khorasan. As can be seen from Figure 5.3, in the Mashhad area qanats with lengths of less than five kilometres are quite common, while there are very few qanats longer than ten kilometres. In Sabzevar, the average length of qanats increases to between three and eight kilometres, and in Gonabad (south of Khorasan) the average length of qanats increases further to about five to ten kilometres. One explanation for such a tendency from the north towards the south may be the increased aridity and thus a greater need to utilize groundwater. However in areas where the source of a qanat is a spring (as it is common in mountainous areas of Birjand), the length of qanats is usually short (200-1000 m).

The depth of the mother well also varies significantly. An observation of qanats' mother wells in Sabzevar and Gonabad areas (Figure 5.4) suggests that unlike areas where larger systems of qanats are constructed e.g. Mashhad, the concentration of mother wells with shallow depths is lower. As shown by Figure 5.4 in Gonabad at least four mother wells are recorded with a depth of about 250 metres and one recorded mother well has a depth of about 300 metres. However, this is the case for qanats constructed in the plains where the source is the water table. In the case of spring-fed qanats which are constructed in mountainous areas the depth of the mother well does not usually exceed 30 m.

Qanats' discharge : Qanat discharge is a function of the productive capacity of the aquifer and the water bearing section of the qanat. Clearly then any fluctuation in the height of the water table will subsequently lead to variations in discharge.

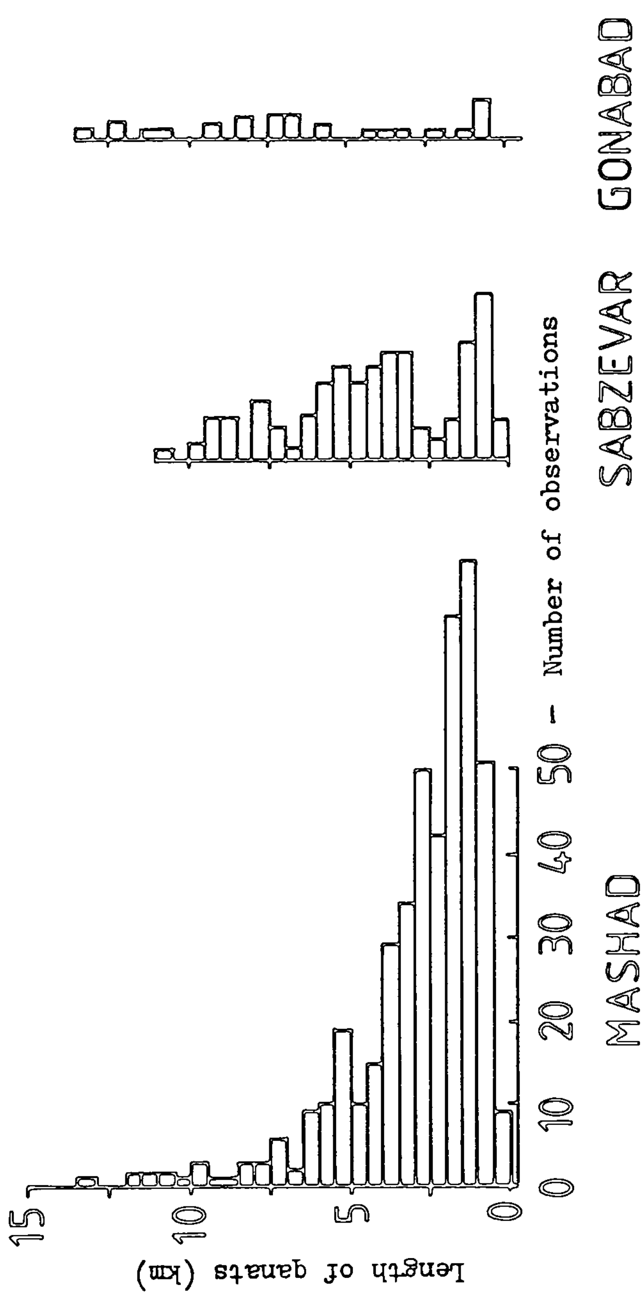


Figure 5.3 Length of qanats around Mashhad, Sabzevar and Gonabad. (after Beaumont, 1971).

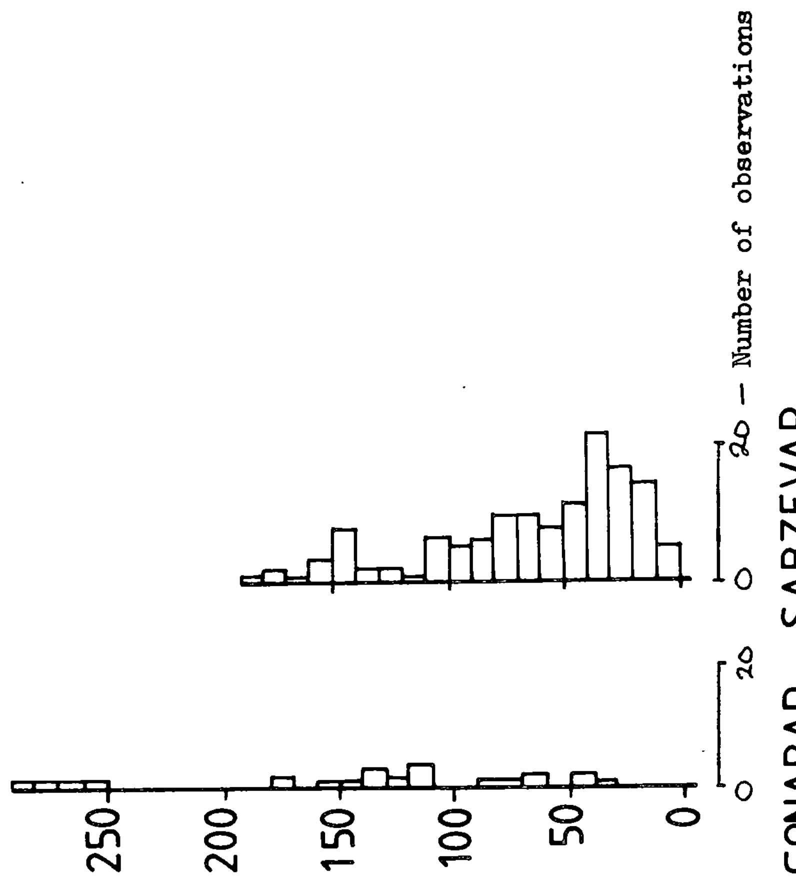


Figure 5.4 Depth of mother wells around Gonabad and Sabzevar. (after Beaumont, 1971).

The discharge figures of the qanats for different areas of Khorasan so far investigated by the Ministry of Water Supply are given in Table 5.1. According to this source the total discharge for qanats in Khorasan region is approximately 1,373 million m^3, of which 242.7 million m^3 (17.7 per cent) is distributed in the north; 765.2 million m^3 (55.7 per cent) in the centre and the remaining 365.1 million m^3 (26.6 per cent) in the south. The lower proportion in the north is partly due to fewer qanats in the area, and partly due to the fact that the major source of groundwater supply in the north are wells (constituting some 77.6 per cent of the total groundwater discharge in northern Khorasan). Although the proportion of qanat discharge is higher in the south, compared with the north, in fact the volume of discharge is very limited since the southern region comprises more than half of the total provincial area and 34 per cent of the settled villages (Village Gazetteer of Khorasan Province 1982). Moreover, qanats are the major source of water supply in the southern region.

Among the plains of Khorasan, Birjand with 223.4 million m^3, Neyshabur with 185.3 million m^3, Mashhad with 130 million m^3, and Torbat-e-Heydariyeh with 136.4 million m^3 have respectively, the largest amount of qanat discharge per annum (see Table 5.1).

A more detailed investigation carried out in the Mashhad area included measurement of monthly variation for 24 selected qanats during the two year period 1964-1965 (Figure 5.5). As can be seen from this figure, the majority of the qanats show maximum discharges occurring during the late Winter and Spring, especially during the period February to May when, as a result of higher precipitation levels and snow melt,

Table 5.1 Number and distribtuion of qanats

Area	Number of qanats 1966	Number of qanats 1976	Actual change	% in 1966	% in 1976
Mashhad	576	250	-326	11.5	7.4
Quchan-Shirvan	176	176	-	3.5	5.2
Dargaz	81	76	- 5	1.6	2.2
Bojnurd	105	90	- 15	2.0	2.6
Total North	938	592	-346	18.6	17.4
Neyshabur	505	623	+118	10.0	18.4
Sabzevar	388	433	+ 45	7.7	12.8
Torbat-e-Jam	229	112	-117	4.5	3.3
Torbat-e-Heydariyeh	451	312	-139	9.0	9.2
Bakhexr	92	110	+ 18	1.8	3.2
Esfarayen	101	117	+ 16	2.0	3.4
Kashmar	190	136	- 54	3.7	4.0
Total Central	1,956	1,843	-113	38.7	54.3
Birjand	1,491	690	-801	29.7	20.4
Gonabad	229	88	-141	4.5	2.6
Ferdows	169	142	- 27	3.3	4.2
Tabas	225	18	-207	4.4	0.5
Total South	2,114	938	-1,176	41.9	27.7
Khorasan	5,008	3,373	-1,635		

Sources: Village Gazetteer (1966)
Plan Organization Statistical Yearbook (1979)

NB There are some variations in the way in which the 1966 and 1976 data were calculated in the original survey. This may account for some minor discrepancies in the calculations on this table.

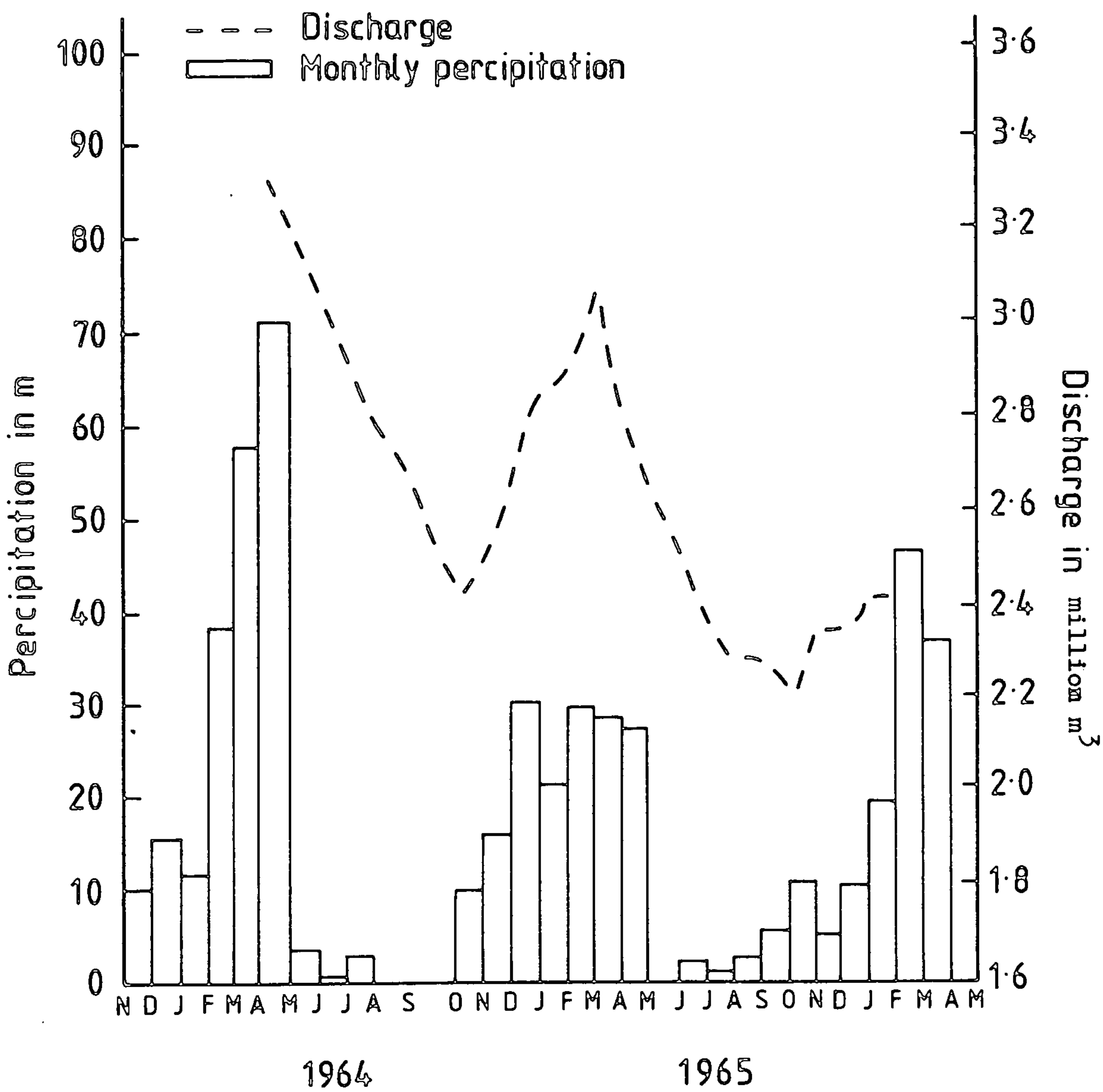


Figure 5.5 Discharge of qanats around Mashhad and its relation to rainfall (based on Beaumont, 1971).

the recharge is higher. By contrast, in the Autumn and Summer months when the amount of rainfall is very low, the discharge is at its minimum. This observation of variation in qanat's discharge, although of limited duration, indicates that there is a marked correlation between precipitation amount and the qanat discharge.

A recorded measurement of qanat discharge in Mashhad plain also suggests that a significant decline in the discharge of qanats occurred during the 1962-69 period. As shown by Figure 5.6 during this period the annual discharge of qanats in Mashhad plain dropped almost three-fold from an annual discharge of 240 million m^3 in 1962 to 95 million m^3 in 1969. This is, however, not surprising if one considers the remarkable increase of pumping discharge in the area. During the same period the discharge of wells increased more than two-fold from 335 million m^3 in 1962 to 760 million m^3 in 1969 (see also Figure 5.6). Another factor which may have also been responsible for lowering the level of the water table and thus a decline in qanat discharge is the noticeable reduction in precipitation. As suggested by the Scet Coop investigation during the same period of 1962-1969, the average amount of annual precipitation in Mashhad station dropped by over 10 mm per cent per annum compared with the average for the 20 years between 1950-1970. (Figure 5.7)

The number and distribution of qanats and their relationship to settlements : According to the Village Gazetteer of Khorasan Province (1966) the number of villages using qanats as a source of water supply was about 5,008. If one assumed that each qanat supports only one village, knowing the fact that there are approximately 8,016 villages in

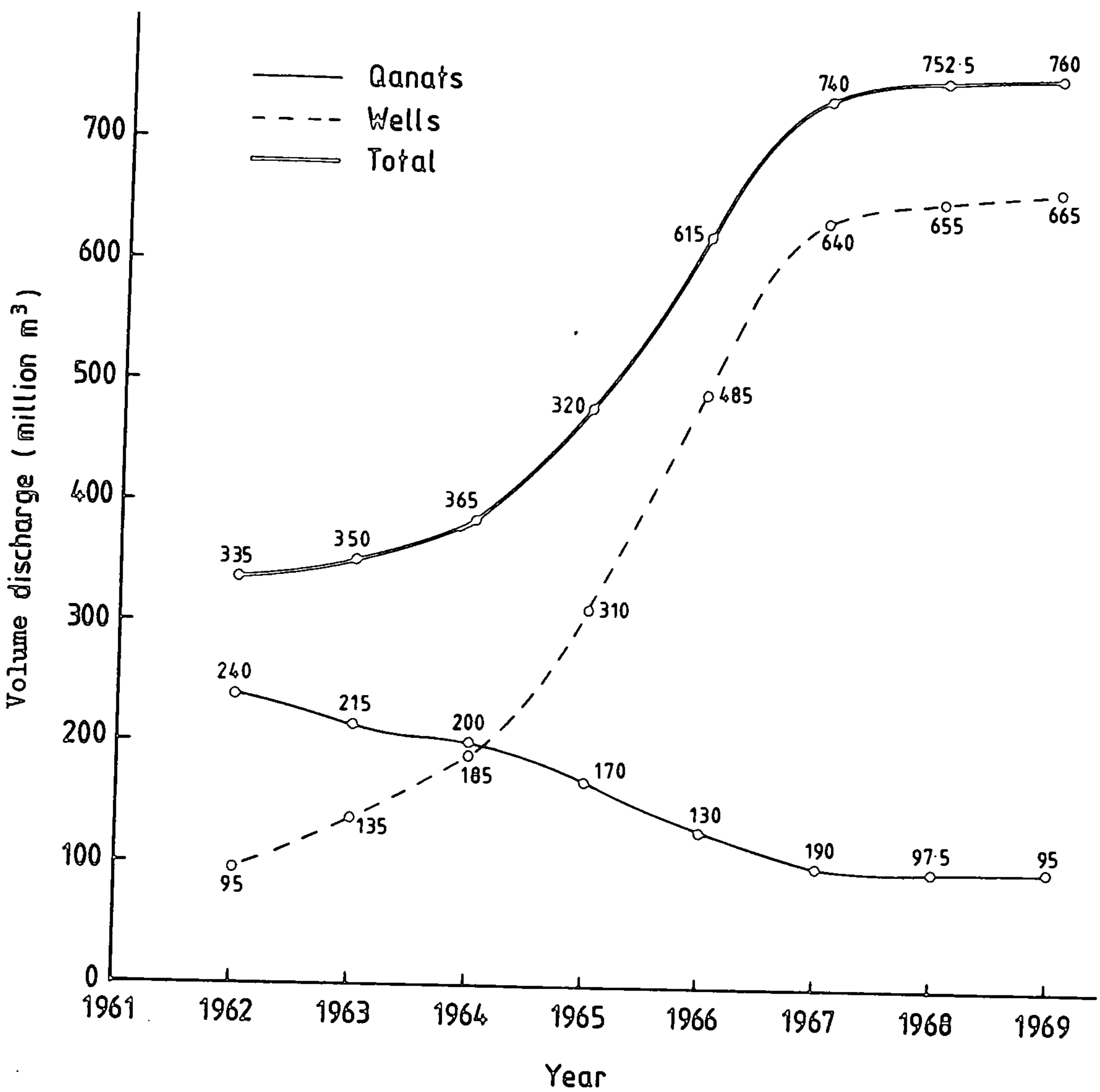


Figure 5.6 The impact of well construction on discharge from qanats during the period 1961-69. (various sources).

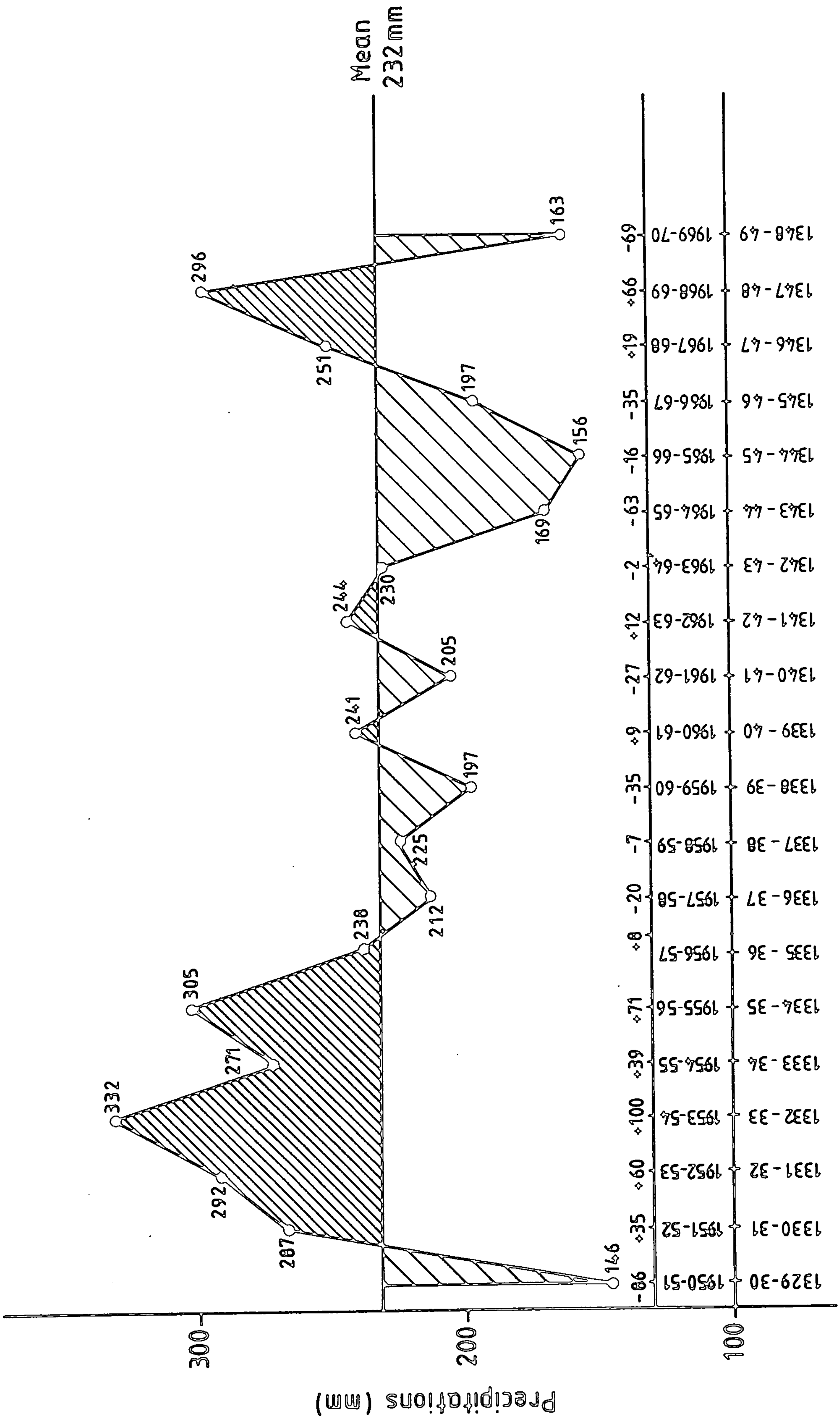


Figure 5.7 Rainfall variations at Mashhad according to SCET COOP.

Khorasan, then it would be reasonable to claim that the life of the majority of the villages in the region (63 per cent) is totally or partially dependent on qanats as a source of irrigation. Naturally, due to increased aridity, this dependency becomes more pronounced in the south, being respectively 36 per cent in the north, 72 per cent in the central and 76 per cent in the southern areas of Khorasan.

However, by comparing the total number of qanats in 1966 and 1976 (Table 5.2) one notices a remarkable decline from a total of 5,008 in 1966 to 3,373 in 1976. The reason for such a drastic decline may be two-fold. Firstly, the 1966 figures are likely to have been over estimated since it was based on the number of villages using qanat sources of water supply while there might have been many cases when a qanat supported more than one village, and secondly the construction of numerous power-operated deep and semi-deep wells in the area. During the decade between 1966-76 the number of deep and semi-deep wells in Khorasan region increased by over five times from 790 to 4,234. Also, as was pointed out earlier, the qanat discharge is a linear function of the level differences between the regional water table and water level in the qanat. Thus heavy pumping of the aquifer results in a fall of the water table and, in turn, leads to the decline in the discharge from qanats and in many cases, to their absolute dryness. In some areas the disastrous effect of heavy aquifer pumping during the 1966-76 period has been aggravated by the effect of the dry period. A good example of such a case is Mashhad plain which, as a result of these combined factors, saw its water table fall in some places by as much as eleven metres (Plan Organization, 1972b). The immediate effect upon qanats was that their volume of discharge decreased and their number was reduced

Table 5.2 Qanat discharge by region (1976)

Area	Total dis-charge	% of Khor-asan	Average annual volume discharge/sec (litres)	Maximum volume discharge/sec (litres)
Mashhad	130	9.5	18	66
Quchan-Shirvan	52	3.8	18	95
Dargaz	22	1.6	9	35
Bojnurd	38.7	2.8	17	45
Total North	242.7	17.7		
Neyshabur	185.3	13.5	11.5	150
Sabzevar	79	5.7	9	90
Jovain	97.6	7.1	12	100
Torbat-e-Jam	55	4.0	15.6	60
Torbat-e-Heydariyeh	136.4	9.9	19	85
Bakhezr	66	4.8	19	85
Esfarayen	49.9	3.6	12	50
Kashmar	97	7.1	25	110
Total Central	765.2	55.7		
Birjand	223.4	16.3	11.4	130
Gonabad	78.1	5.7	19	134
Ferdows	33.6	2.4	8	170
Tabas	30.0	2.7	9	55
Total South	365.1	26.6		
Khorasan	1373			

Source: Plan Organization Staistical Yearbook (1979) from 576 in 1966 to 250 in 1976 (Village Gazetteer of Khorasan Province 1966; Statistical yearbook 1979).

The percentage distribution of qanats in different plains of Khorasan (Table 5.2) indicates that central basins of Khorasan, particularly Neyshabur (which was once reported to have 12,000 qanats, Naini, 1978) and Birjand in the south, have the largest proportion of qanats. In some of the heavily cultivated and populated plains such as Mashhad and Nishapoor, a great number of qanats have gradually been replaced by power-operating deep and semi-deep wells. One of the responsible factors for such a trend was the effect of the land reform law of 1962 which, as is evidenced by the following statement from Lambton (1969, p.289), encouraged the landowners to turn over the irrigation system to power-operated wells:

> In parts of Khorasan, notably Neyshabur, the development of power-operated deep and semi-deep wells has adversely affected land reform in the following way. If the land is settled by division under the second stage, i.e. divided between the peasants and the landowners in the same proportion as the crop was divided under the crop-sharing division, or the landowner retains mechanized land in the village, he is often able, without contravening the law, to sink a deep or semi-deep well in his part of the village land. The effect of this may be to lessen the flow of the qanats watering the rest of the land or to dry them up altogether so that the peasants receiving land are not able to obtain a living from it."

In Khorasan, as with other arid and semi-arid regions of Iran e.g. Yazd and Kerman, qanats play a decisive role in the formation, expansion and distribution of rural settlements. This is quite evident from the universal use of qanats in the area as shown by the maps of villages using qanats (Figures 5.8, 5.9, and 5.10). These figures also indicate that there is a marked variation in the distribution and pattern of villages using qanats as a source of irrigation. In the north a denser concentration of qanats is found along the Atrak-Kashaf valley from Bojnurd to Mashhad and thus the pattern is linear shape. In the central areas of Khorasan the pattern has a clustered shape, which is determined by the geographical location of underground water resources, on which the existence of the agriculture of the area, through the qanat source of irrigation, is dependent. In the south, the marginal highland areas of the east (Birjand, Qaen and Gonabad areas) exhibit the largest concentration, while the extensive desert area to the west is almost bare and the villages using the qanat source of irrigation are very sparsely distributed.

Problems of irrigation by qanat: The main problems of irrigation by qanats are as follows :

i) Discharge is uncontrolable - One of the major problems of the qanat system of irrigation is that its discharge is uncontrolable. This means that during the period when irrigation is not needed, the water runs to waste. In fact it is only in the dry season of Summer that the water discharge is efficiently used by day and night irrigation. For the rest of the year qanats only serve domestic needs and pass the cultivated areas unused. It is interesting to note that of the total

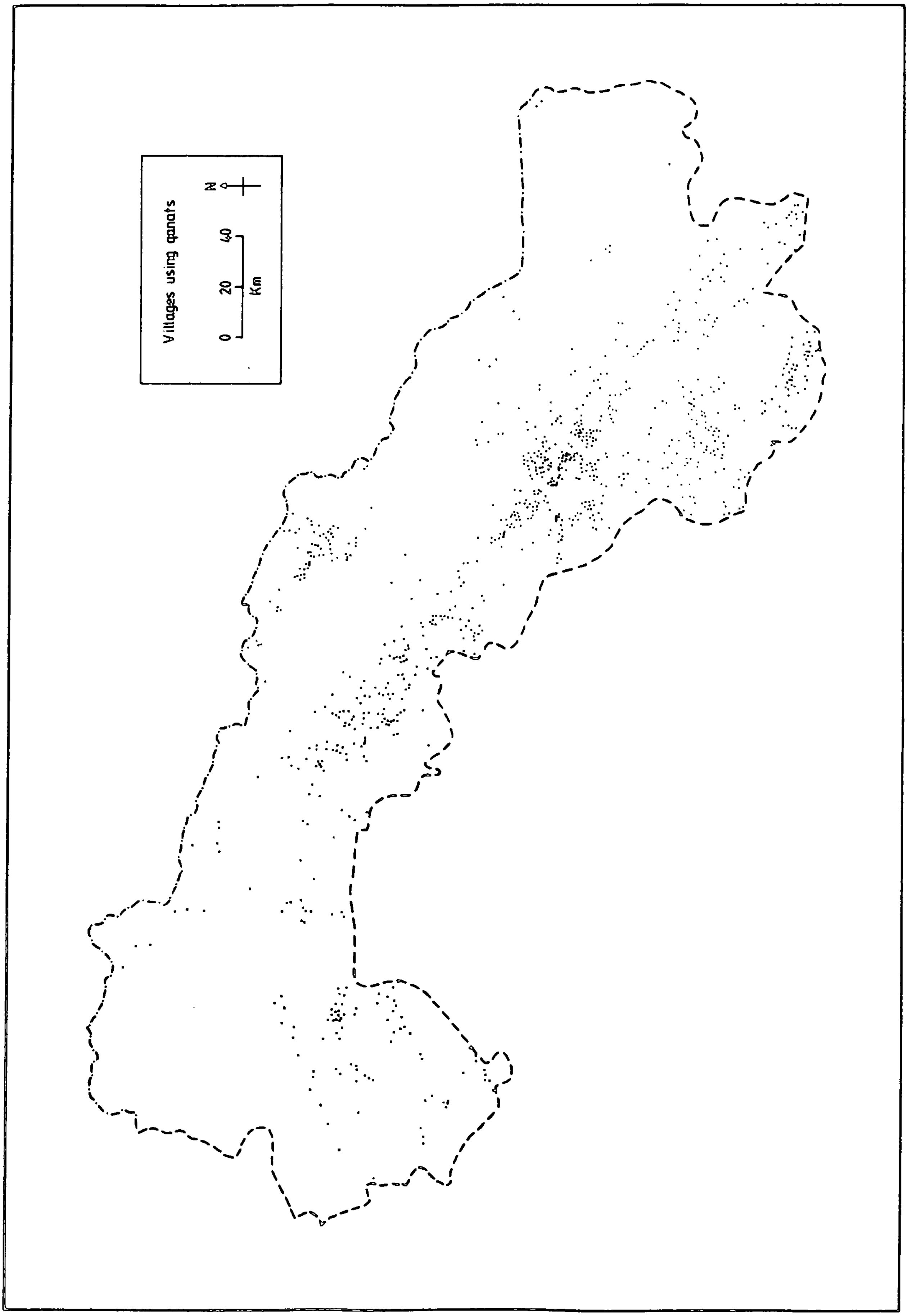


Figure 5.8 Villages relying on qanats for water supply in 1966 (north)

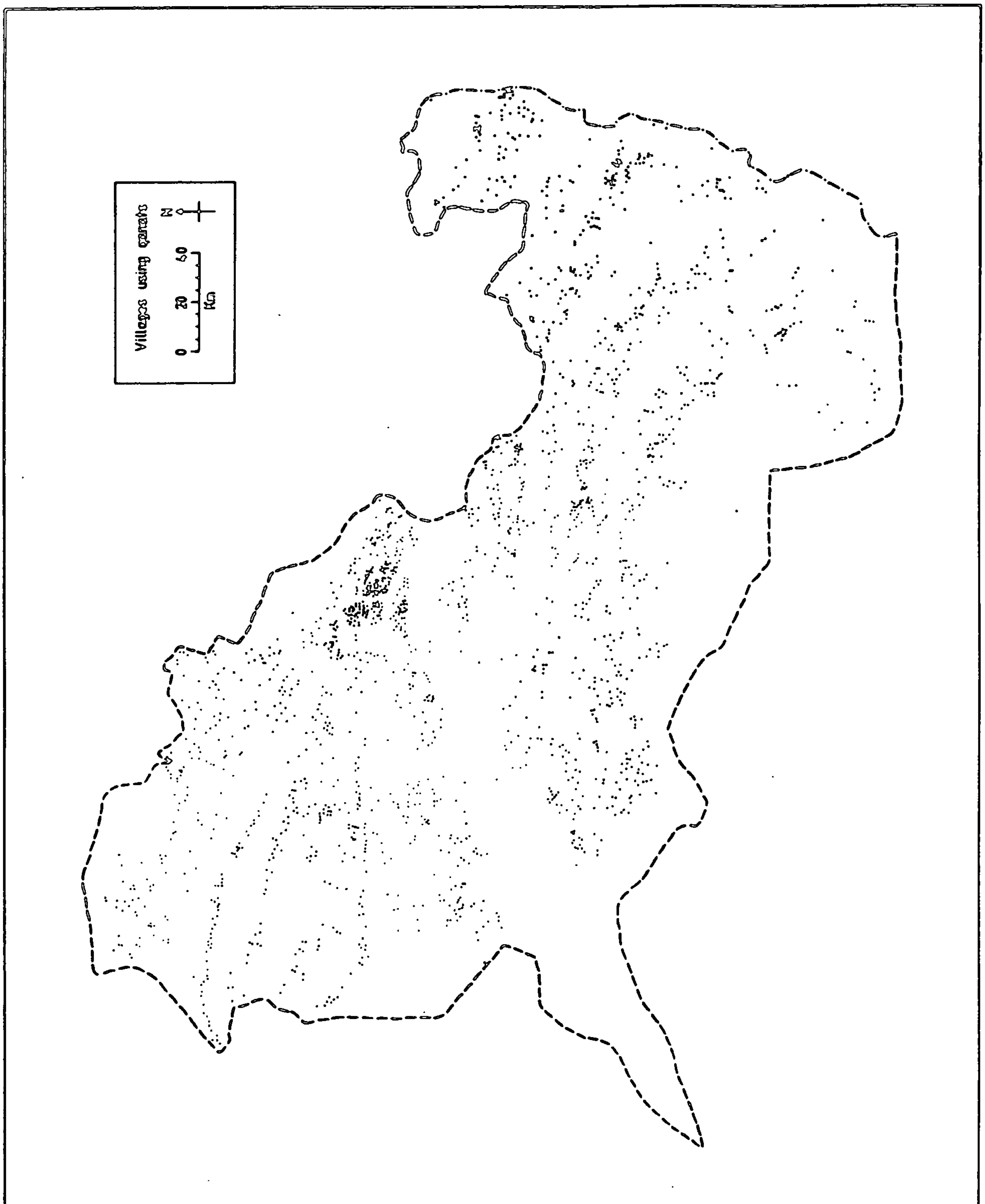


Figure 5.9 Villages relying on qanats for water supply in 1966 (centre)

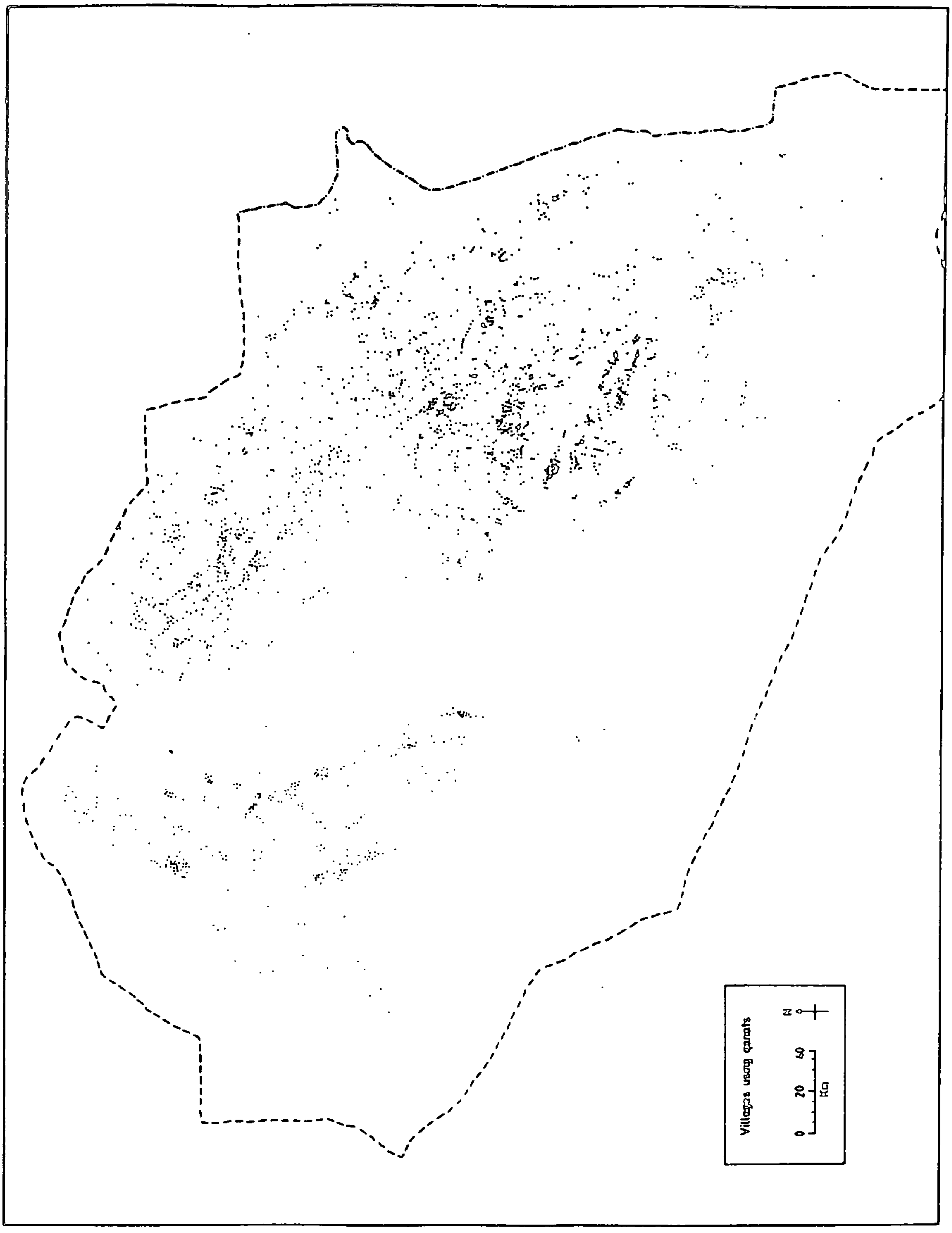


Figure 5.10 Villages relying on qanats for water supply in 1966 (south)

estimated average 31,000 cubic metres (m^3) discharge of a qanat in a year, only 13,000 cubic metres (41.9 per cent) are consumed annually for irrigation (Plan Organization 1963). Although the effect of annual loss of 18,000 m^3 (or 58.1 per cent) of the total annual discharge of a single qanat may not be serious regionally, the loss from several thousand qanats in the area is disasterous and therefore must be of great concern. In some villages of Khorasan, notably in the Mashhad area, the problem of diurnal losses is reduced by the construction of storage-ponds to divert the night discharge of the qanat and store the water for the following day's irrigation. Such ponds provide very limited capacities and the evaporation losses from them are considerable but to a certain extent they increase the efficiency of the qanats' discharge.

ii) The high cost of upkeep and construction - Owing to the convectional rain which usually occurs in the area during the Spring season qanats in Khorasan are often in danger of collapse and thus they need constant attention and repair. The upkeep of qanats is usually an expensive operation. Naturally it is very difficult to estimate the average cost of upkeep as the cost varies greatly from one qanat to another depending upon the extent of the damage, length and the nature of the soil in which qanats flow through. The softness of the soil means that subsidence in the underground channels is likely to be frequent and repairs are required more often.

It is also quite difficult to calculate the average construction costs of qanats in monetary terms, as wages are paid both in kind and cash, and the estimated cost usually varies from one source to another.

Paul English states that a 29 kilometre qanat to Kerman, completed in 1950, cost $213,000 and estimated the average cost per kilometre in 1960 at $10,000. Beaumont (1971) also referred to an average cost of $10,000 per kilometre. In the case of Javadiyeh qanat with a length of three kilometres, Golabian (1977) calculated a rough estimated cost of $33,000 or $11,000. Finally Lambton (1969) gave the following estimation of the average cost of qanats in Qazvin area.

> "It was estimated that the average cost of digging a qanat in the Qazvin area, where they averaged from three to five miles in length and 100 ft in depth was 2,000,000 rs (£9,090) which was roughly the same as the cost of sinking a well of 150-300 ft. together with the installation of an engine and pump."

iii) Problems of qanat's water distribution - Due to the large number of share owners from the qanats water (in some cases the water from a qanat may be divided into 10,000 or more shares. English, 1968), the distribution of qanat's water is a complicated operation in the Iranian irrigation system and often a cause for dispute. Thus, in larger villages and particularly during the drought period, a local man known as Mirab is employed to divide the water among the plots of cultivated land and make sure that every plot gets its own rotation of water according to traditional custom.

The other major problem with qanats is that they take many years to construct. English (cited by Beaumont 1971), refers to a case that one qanat near Kerman, three kilometres in length, took one team of qanat diggers working daily seventeen years to construct.

However, despite the above mentioned problems, qanats in Khorasan and in particular in the more arid central and southern areas, are still the most widely used source of irrigation for its several advantages (a) it requires no source of power for the transformation of water other than gravity; (b) by this method water can be transmitted to the low rainfall regions and this allows the cultivation in areas which would otherwise be marginal or totally unproductive land; (c) once constructed, it will continue to supply water for long periods and unlike wells it causes no risk of over exploitation of groundwater resources and finally (d) the danger of pollution and water losses from seepage and evaporation are minimal.

WELLS

In the areas where the construction of qanats is not possible for topographical reasons, or the supply by qanat is insufficient, wells are an important solution to the problems of water shortage. Prior to 1966 the impact of wells on settlements in Khorasan was limited. The total number of wells (790) reported by the village Gazetteer (1966) was clearly outnumbered by qanats (5,008).

Distribution: The very uneven distribution of wells over the region and within each main sub-division (north, central and south Khorasan) is illustrated by Figures 5.11, 5.12, and 5.13. In the south, the absence of the pumping wells is quite clear and, as can be seen from Figure 5.13, there are only a few wells found in the area (84 or 10.6 per cent of the region's total). The reasons for such a small proportion in the south is that the reservoir of the groundwater in this part of Khorasan is much smaller than in other regions. Another explanation is the

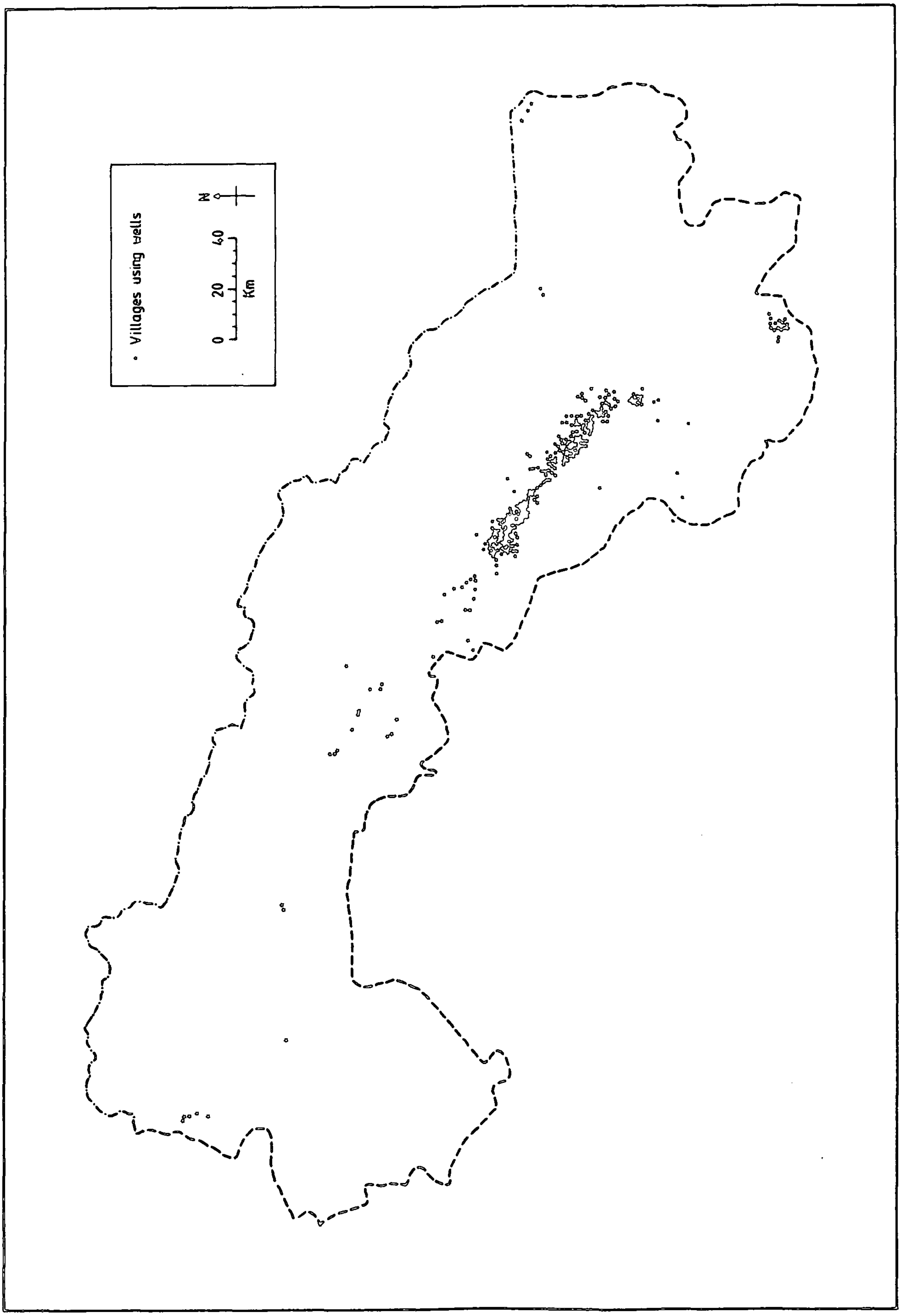


Figure 5.11 Villages relying on wells for water supply in 1966 (north)

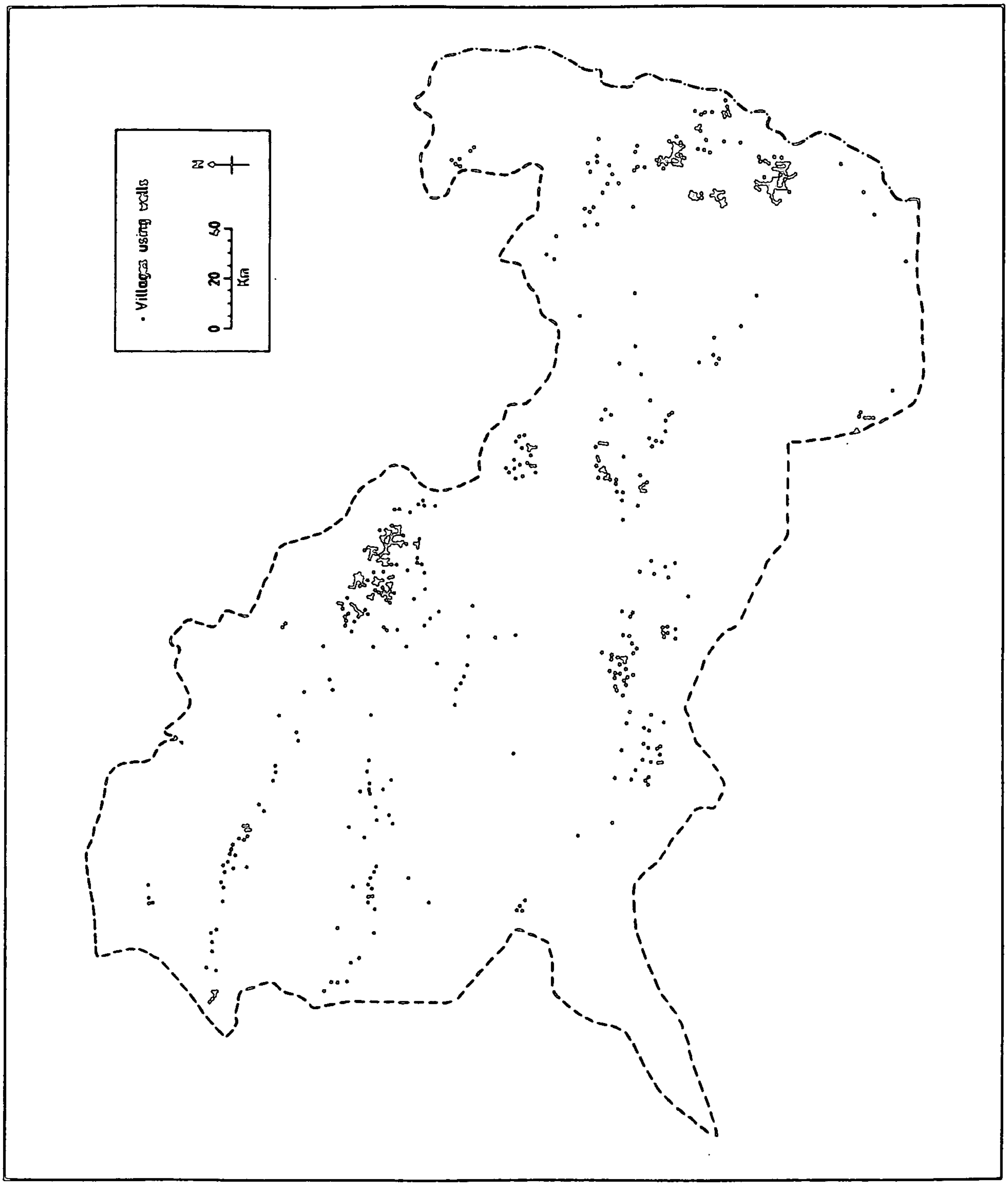


Figure 5.12 Villages relying on wells for water supply in 1966 (centre)

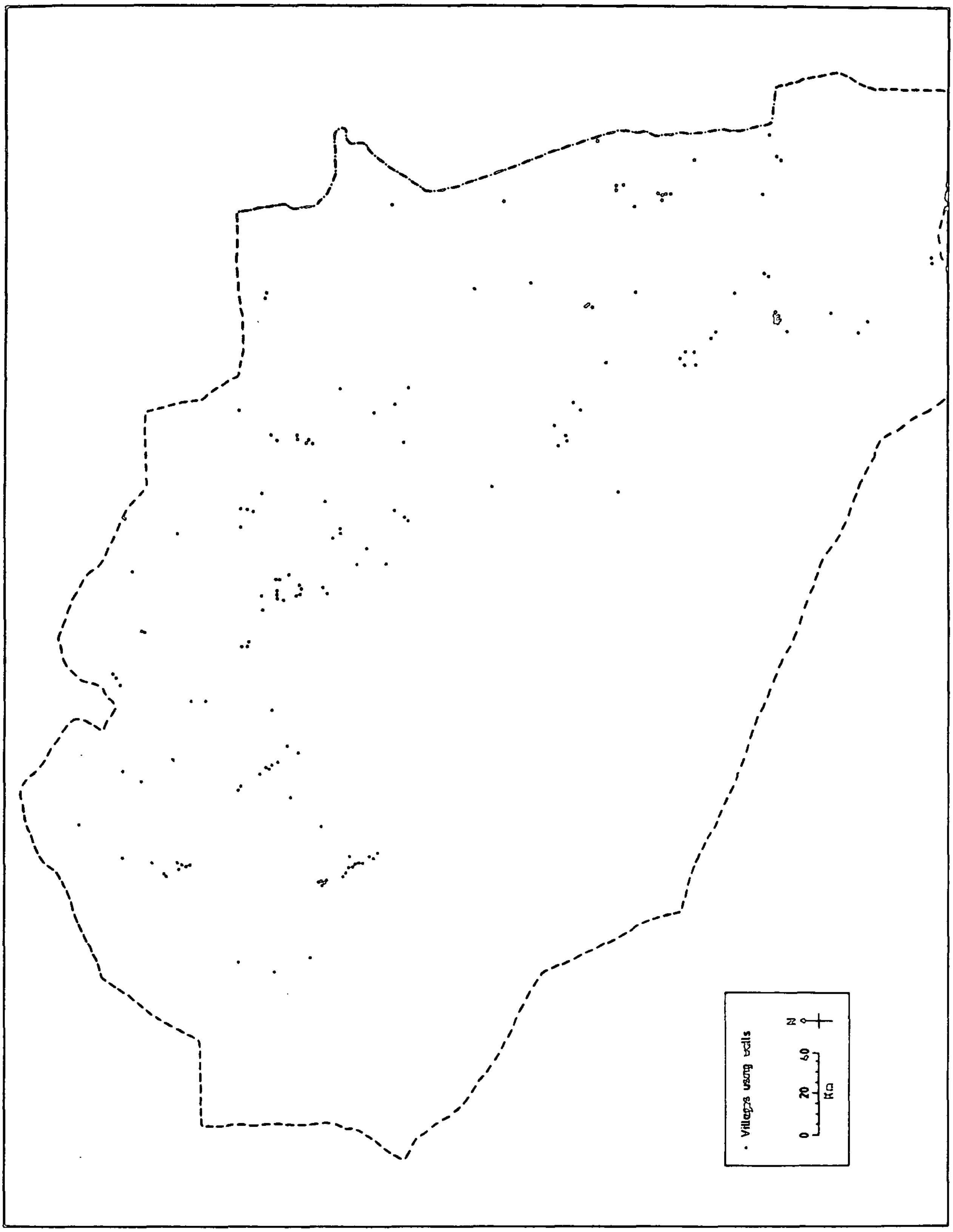


Figure 5.13 Villages relying on wells for water supply in 1966 (south)

region's lack of good agricultural land as well as its isolation from the large cities which makes the investment of capital in wells uneconomic. The central and northern areas of Khorasan had the largest proportion of concentration of wells in 1966 - 52.4 and 73 per cent of the total (790) respectively. Mashhad in the north, Nishapoor, Sabzavar, Kashmar and Torbat-e-Haydariyeh plains in central Khorasan had the largest concentration of wells. The maps of north and central Khorasan showing well distribution (Figures 5.11 and 5.12) also indicate that the wells are most densely concentrated in the neighbourhood of the large cities, where the transportation of commercially produced crops is much easier and more economic.

However, during the 1966-76 period the number of deep and semi-deep wells in the area greatly increased, from 790 in 1966 to a total of 4,234 in 1976. As shown by Table 5.3 it is again the north and central areas of Khorasan which contain the largest proportion 44.8 and 47 per cent respectively, while, for the reasons referred to earlier, the extensive arid southern areas have only hosted 346 (8.2 per cent) of the total number of wells in Khorasan. Table 5.3 shows that the majority of new wells constructed during the 1966-76 period were located in the north and central areas of Khorasan, particularly around Mashhad and Nishapoor.

Wells' discharge: One of the advantages of wells is that, unlike qanats, the discharge is controllable, and therefore at the time when wells are not operating (e.g. Winter), water remains in the groundwater storage to be utilized when needed. It was partly for the same reason that the construction of wells was encouraged and facilitated by the government. As a result the total discharge of wells in the region

Table 5.3 Number and distribution of wells

Area	Number of wells 1966	Number of wells 1976	Absolute change	% in 1966	% in 1976
Mashhad	248	1,431	+1,183	31.4	33.8
Quchan-Shirvan	31	328	+ 297	3.9	7.7
Dargaz	4	46	+ 42	0.5	1.1
Bojnurd	9	91	+ 82	1.1	2.2
Total North	292	1,896	+1,604	36.9	44.8
Neyshabur	172	427	+ 255	21.7	10.1
Sabzevar	71	369	+ 298	8.9	8.7
Torbat-e-Jam	7	481	+ 474	0.8	11.4
Torbat-e-Heydariyeh	85	339	+ 254	10.8	8.0
Bakhezr	14	90	+ 76	1.8	2.1
Esfarayen	3	81	+ 78	0.4	1.9
Kashmar	62	205	+ 143	7.8	4.8
Total Central	414	1,992	+1,578	52.3	47.0
Birjand	40	204	+ 164	5.2	4.8
Gonabad	7	11	+ 4	0.8	0.3
Ferdows	8	105	+ 97	1.1	2.5
Tabas	29	26	- 3	3.7	0.6
Total South	84	346	+ 262	10.8	8.2
Khorasan	790	4,234	+3,444		

Sources : Village Gazetteer (1966)
Plan Organization, Statistical Yearbook (1979)

NB There are some variations in the way in which the 1966 and 1976 data were calculated in the original survey. This may account for some minor discrepancies in the calculations on this table.

increased by about 42 per cent from 1,409 million m^3 in 1968 to 2,438.1 million m^3 in 1976.

Table 5.4 shows the discharge condition of deep and semi-deep wells in Khorasan by region. As can be seen with its small number of constructed wells the south of Khorasan accounted for only a negligible amount of the total discharge, about 3.9 per cent of the total 2438.1 million m^3 of the province. The remaining 96.1 per cent is almost equally distributed between north and central Khorasan. Among the different plains, Mashhad has by far the largest amount of discharge. It alone contributed to 90.1 per cent and 44 per cent respectively of water discharge in the north and the province as a whole. It is also interesting to note that the 1072 million m^3 discharge of power-operated deep and semi-deep wells in Mashhad plain is higher by 217 million m^3 (25.4 per cent) than its total annual potentiality estimated by SCET COOP. In other words approximately 217 million m^3 of extra water is needed each year to recharge the supply.

Problems of irrigation by wells: As will be explained in later sections almost all the major plains of Khorasan, notably Mashhad, Nishapoor, Torbat-e-Jam, Torbat-e-Haydariyeh have excessively exploited their groundwater reservoir and thus have seen their level of water table lowered considerably. For Khorasan as a whole the amount of over-utilisation of the groundwater reservoir reaches to as much as 1000 million m^3. One major factor responsible for such a remarkable overdraw is the uncontrolled heavy exploitation of the aquifer by numerous deep and semi-deep wells constructed in the area since about 1960. The effect of the falling water table upon qanats was inevitable. It

Table 5.4 Wells discharge by regions (1976)

Area	Total discharge	% of Khorasan	Average annual volume discharge/sec (litres)	Maximum volume discharge /sec (litres)
Mashhad	1,072	44.0	33	80
Quchan-Shirvan	53	2.2	22	65
Dargaz	20	0.8	22	55
Bojnurd	44.6	1.8	33	45
Total North	1,189.6	48.8		
Neyshabur	260.5	10.7	33	120
Sabzevar	132.1	5.4	24	70
Torbat-e-Jan	397	16.3	25	75
Torbat-e-Heydariyeh	138.4	5.7	31	80
Bakhezr	66	2.7	29	70
Esfarayen	29.6	1.2	29	100
Kashmar	131	5.4		30
Total Central	1,154.6	47.4		
Birjand	56	2.3	25	75
Gonabad	2.3	0.1	10	15
Ferdows	35.6	1.4	30	60
Tabas	0	0	0	0
Total South	93.9	3.8		
Khorasan	2,438.1			

Source: Plan Organization Statistical Yearbook (1979) resulted in many of them having their discharge reduced and some were totally abandoned.

Despite their negative effect upon the water table and thus upon the qanats as well, and the fact that they are very costly (ranging between $3000 to $15000, Beaumont 1971), wells make the largest contribution to groundwater discharge in Khorasan and outnumbers the qanats by approximately 20 per cent. This is mainly due to two main advantages: (a) unlike qanats the water supply of wells is controlable and water does not run to waste during the times when it is not needed and (b) unlike qanats which take many years to construct, the construction of wells takes only one or two months.

SPRINGS

The water received from springs is used for drinking, household purposes and irrigation. In many villages of Khorasan springs are the only source of drinking water and therefore the places where they emerge on the surface have an important role in the location of villages. However, in some areas, the sinking of shallow and deep wells and the construction of pipe systems for the transportation of drinking water have reduced the influence of springs on settlement patterns during the last three decades.

Despite the great number of springs in Khorasan (7400 were reported by the agricultural census of Iran conducted in 1973) the majority are seasonal and their volume of discharge is too small to make anything other than a minimal contribution to consumption.

Table 5.5 shows the number, distribution and discharge of the largest springs in Khorasan. As shown, the amount of spring water discharge in comparison to qanats and wells is much less and contributes only 195.1 million m^3 (4.9 per cent) of the total groundwater discharge of the region as a whole. Approximately 51.8 per cent of the total spring discharge is found in northern Khorasan and in particular in Bojnurd, Dargaz and Quchan areas where recharge supply and geological conditions are more favourable. In these areas, springs play an important role in the formation, expansion and distribution of the villages. In Bojnurd there are many villages with the suffix or prefix of chashmeh (spring) such as : Chashmeh Ayyub, Chashmeh Godormand, Chashmeh Gul, Sur Chashmeh, Agh Chashmeh, Taydal Chashmeh, Suyukh Chashmeh and Pan Chashmeh.

Towards the south the volume of discharge by springs is sharply reduced, being respectively 30.5 per cent and 17.8 per cent in the centre and south (see also Table 5.5).

TRENDS IN TOTAL GROUNDWATER SUPPLY 1966-76

As already explained, of the total 7,971 sources of water supply in 1976 there were 3,373 (42.3 per cent) qanats, 4,234 (53.9 per cent) wells and the remaining 364 (4.5 per cent) were springs. By comparing these figures with those given by the village Gazetteer in 1966, one notices a remarkable variation in the trend between the number of qanats and wells. While the former declined in number by 1,635 or approximately 33 per cent the latter had an increase of 3,444 or 81 per cent. Although this was a general trend throughout the region, the extent of change varied considerably from one area to another. Southern

Table 5.5 Number of discharge of major springs by major and sub-divided areas

Area	Number		Discharge	
	Number	%	Million m	%
Mashhad	15	4.1	9	4.6
Quchan-Shirvan	17	4.7	19	9.7
Dargaz	51	14.0	34	17.4
Bojnurd	48	13.2	39.1	20.0
Total North	131	36.0	101.1	51.7
Neyshabur	51	14.0	11.8	6.0
Sabzevar	11	3.0	2.5	1.3
Torbat-e-Jam	0	0	0	0
Torbat-e-Heydariyeh	8	2.2	7.8	4
Bakhezr	8	2.2	4.0	2.1
Esfarayen	26	7.1	17.8	9.1
Kashmar	7	1.9	15.5	8.0
Total Central	111	30.4	59.4	30.5
Birjand	84	23.1	23.5	12.1
Gonabad	6	1.7	1.3	0.7
Ferdows	32	8.8	9.8	5.0
Tabas	0	0	0	0
Total South	122	33.6	34.6	17.8
Khorasan	364		195.1	

Source : Plan Organization (1972)

areas of Khorasan not only had the greatest loss of qanats, by approximately 1,176 or 57 per cent, but also gained the smallest share in the increased number of wells (only 262 or 7.6 per cent of the total 3,444 new wells). As a result it lost, as a whole, 914 or approximately 41 per cent of its total major water supply (wells and qanats put together) since 1966. Although the percentage decline in the number of qanats in the north was relatively high (36.8 per cent of the 938 qanats in 1976), that loss was compensated for by the large increase in the number of wells (by 1,604 or approximately 84.6 per cent). The central areas of Khorasan had the highest net increase of 1,465 (wells and qanats put together) as it accounted for the lowest proportion of loss in qanats (by only 5.8 per cent) and a relatively large proportion of the increased number of wells (1,578 or 79.2 per cent).

Among the sub-divided areas, only the southern shahrestans of Birjand, Gonabad and Tabas had a loss in their total number of major water supply (qanats and wells put together) while the remaining majority of shahrestans tended to increase. Birjand had the greatest loss by 637 or 42 per cent and Mashhad had the highest increase by 857 or 51 per cent.

In Khorasan, due to the shortage of precipitation and surface water, groundwater resources (qanats, wells and springs) play a major role in the location, distribution and the expansion of the villages. The fact that the number of sources of total groundwater supply is almost equal to the number of settlements is a clear indication of such an important role. However, it should be stated that the geographical interaction between the villages and source of water supply may vary from one area to another or from one village to another, depending on the characteristics of the groundwater system, especially discharge, topographical conditions, the size of villages, area of cultivation, the proximity of the village to the large town and the availability of capital investment. A village may have only one source of water supply. In this case the village is usually small and the qanat is the most common source of water supply. A great majority of the villages in southern areas of Khorasan, such as most of the hamlets and the isolated villages in the marginal desert areas fall into this category.

A village may have more than one source of water supply, usually one qanat and one supplementary well. There are also cases when a large village has a number of water sources. It can be several qanats, or one or more qanats which are supplemented by one or more wells. This latter case is often observed in the periphery of the large towns where both the proximity of a large market and the better quality and quantity of the groundwater reservoir encourages capital investment for the construction of wells. Good examples are Mashhad, Neyshabur and Torbat-e-jam areas, which comprised 55 per cent of the total number of wells in Khorasan. The total number of groundwater supplies is given by Table 5.6, by regions and by major source (qanats, wells and springs).

To show the degree of relationship between the villages and water supply, the variation in the number of these two variables were tested using the Spearman's Rank Correlation Coefficient Table 5.7. . The calculation is set out on the basis of the 1976 village Gazetteer and the Ministry of Water Supply investigation in 1976. The result of the test indicated that the frequency of water supply in Khorasan is not randomly correlated to the

Table 5.6 Water supplies by regions and major sources (1976)

Area	Qanat		Well		Spring		Total	
	Number	%	Number	%	Number	%	Number	%
Mashhad-Sarakhs	250	7.4	1,431	33.8	15	4.1	1,696	21.3
Quchan-Shirvan	176	5.2	328	7.7	17	4.7	521	6.5
Dargaz	76	2.3	46	1.1	51	14.0	173	2.2
Bojnurd-jajarm	90	2.7	91	2.2	48	13.2	229	2.9
Total North	592	17.6	1,896	42.8	131	36.0	2,619	32.9
Torbat-e-jam	112	3.3	481	11.4	-	-	593	7.4
Bakhezr	110	3.3	90	2.1	8	2.2	208	2.6
Torbat-e-Heydariyeh	312	9.2	339	8.0	8	2.2	659	8.3
Sabzevar-jovain	433	12.8	369	8.7	11	3.0	813	10.2
Kashmar	136	4.0	205	4.8	7	1.9	348	4.4
Esfarayen	117	3.5	81	1.9	26	7.1	224	2.8
Neyshabur	623	18.5	427	10.1	51	14.0	1,101	13.8
Total Central	1,843	54.5	1,992	47.0	111	30.4	3,946	49.5
Birjand	690	20.5	204	4.8	84	23.1	978	12.3
Gonabad	88	2.6	11	0.3	6	1.7	105	1.3
Ferdows	142	4.2	105	2.5	32	8.8	279	3.5
Tabas	18	0.5	26	0.6	-	-	44	0.5
Total South	938	27.8	346	8.2	122	33.6	1,406	17.6
Khorasan	3,373	100	4,234	100	364	100	7,971	100

Source : Plan Organization, Statistical Yearbook, 1979.

Table 5.7 Spearman's Rank analysis of water supply distribution in Khorasan (1976)

The number of villages is not related to those observed with water supply

Area	Number of villages (rank)	Number with water supply (rank)	d	d^2
Mashhad	2	1	1	1
Quchan-Shirvan	6	7	1	1
Dargaz	15	13	2	4
Bojnurd	4	10	6	36
Torbat-e-Jam	8	6	2	4
Bakhezr	13	12	1	1
Torbat-e-Heydariyeh	5	5	0	0
Sabzevar	7	4	3	9
Kashmar	10	8	2	4
Esfarayen	14	11	3	9
Neyshabur	3	2	1	1
Birjand	1	3	2	4
Gonabad	12	14	2	4
Ferdows	11	9	2	4
Tabas	9	15	6	36

$\Sigma d^2 = 116$ $\quad rs = 1 - \dfrac{6\Sigma d^2}{n^3 - n}$ $\quad rs = 0.79$

Positive correlation is significant at 95% level

Sources: Village Gazetteer of Khorasan (1976)
Plan Organization, Statistical Yearbook 1979

total number of settlements at a confidence level greater than the 95 per cent (Table 5.7).

Total groundwater discharge: Table 5.8 shows the groundwater discharge conditions of Khorasan by the main regions, and by the source of water supply. As shown, the largest share is obtained by wells with approximatley 60.9 per cent of the total provincial 4006.2 million m³. Next in importance are qanats with 34.3 per cent and springs with 4.8 per cent. However, reflected from the number, distribution, and character of water sources, the amount of discharge obtained by each source (wells, qanats and springs) varies from one area to another. North and central Khorasan exhibit a similar trend, both having the largest proportion supplied by wells, with respectively 77.6 and 58.3 per cent of their total water discharge. While in the south the trend is different, it is qanats which are the dominant source of supply comprising approximately 74 per cent of the regions discharge (see (see Table 5.8).

Among the different plains of Khorasan, Mashhad had by far the largest water discharge obtained by wells. It alone constituted 1072 million m³ of 44 per cent of the total regional groundwater obtained by wells. With respect to the source of qanats, Birjand in the south has the largest proportion with approximately 223.4 million m³, followed by the plains of Neyshabur and Torbat-e-Haydariyeh with 16.3 and 13.5 per cent respectively (see also Table 5.8).

Groundwater potentiality: Reflected from recharge and geological conditions, the potentiality of groundwater of Khorasan varies greatly from one region to another. As with many other aspects of the physical

Table 5.8 Discharge of qanats, wells and springs

Area	Qanats		Wells		Springs		Total	
	Discharge million m^3	%	Discharge million m^3	%	Discharge million m^3	%	Discharge million m^3	%
Mashhad-Sarakhs	130	9.5	1072	44.0	9	4.6	1211	30.2
Quchan-Shirvan	52	3.8	53	2.2	19	9.7	124	3.1
Dargaz	22	1.6	20	0.8	34	17.4	76	1.9
Bojnurd-jajarm	38.7	2.8	44.6	1.8	39.1	20.0	122.4	3.1
Total North	242.7	17.7	1189.6	48.8	101.1	51.7	1533.4	38.3
Torbat-e-jam	55	4.0	397	16.3	-		452	11.3
Bakhezr	66	4.8	66	2.7	4.0	2.1	136	3.4
Torbat-e-Heydariyeh	136.4	9.9	138.4	5.7	7.8	4.0	282.6	7.1
Sabzevar-jovain	175.6	12.8	132.1	5.4	2.5	1.3	310.2	7.7
Kashmar	97	7.1	131	5.4	15.5	8.0	243.5	6.1
Esfarayen	49.9	3.6	29.6	1.2	17.8	9.1	97.3	2.4
Neyshabur	185.3	13.5	260.5	10.7	11.8	6.0	457.6	11.4
Total Central	765.2	55.7	1154.6	47.4	59.4	30.5	1979.2	49.4
Birjand	223.4	16.3	56	2.3	23.5	12.1	302.9	7.6
Gonabad	78.1	5.7	2.3	0.1	1.3	0.7	81.7	2.0
Ferdows	33.6	2.4	35.6	1.4	9.8	5.0	79.0	2.0
Tabas	30.0	2.2	-	-	-	-	30.0	0.7
Total South	365.1	26.6	93.9	3.8	34.6	17.8	493.6	12.3
Khorasan	1373	100	2438.1	100	195.1	100	4006.2	100

Source : Plan Organisation, Statistical Yearbook, 1979 environment, favourable conditions for the development of groundwater reservoirs prevail more in the north and central areas of Khorasan where (a) there are more extensive permeable formations such as limestone and alluvium (see Chapter 3) and (b) as previously noticed, the volume of recharge is much greater, either by infiltration of rainfall and snowmelt, or through infiltration of the rivers and streams. These two regions, together, contribute approximately 88 per cent of the total 3010 million m^3 groundwater potentiality of the region (Table 5.9). In the southern areas of Khorasan, although the presence of geological formations suitable for groundwater development are widespread in most parts, it is the recharge supply which is inadequate and the limiting factor. The very negligible potentiality in the south (only an estimated 360 million m^3 or 12 per cent of the total potential) has undoubtedly a disastrous effect on the economy and formation of the villages in the area, particularly if one considers the fact that due to the region's marked aridity and shortage of surface water a great number of villages in the area (31.2 per cent of the total village settlements of Khorasan according to the 1976 census) have to rely on groundwater as a source of irrigation.

It is clear from Figure 5.14 that there is also a noticeable variation in the groundwater potentiality within each area of north, central and southern Khorasan. Mashhad plain has the greatest contribution to potentiality. It alone constitutes 66.4 per cent of the total estimated 1280 million m^3 potentiality of the north and 28.2 per cent of that of the province as a whole. In the central areas, the distribution of groundwater reservoirs is comparatively more even with the Neyshabur and Torbat-e-Jam plains having the largest share of ground

Table 5.9 Groundwater potentiality by major regions.

Area	million m^3	percentage
North	1280	42.5
Centre	1370	45.5
South	360	12.0

Source: Plan and Budget Organisation, 1975.

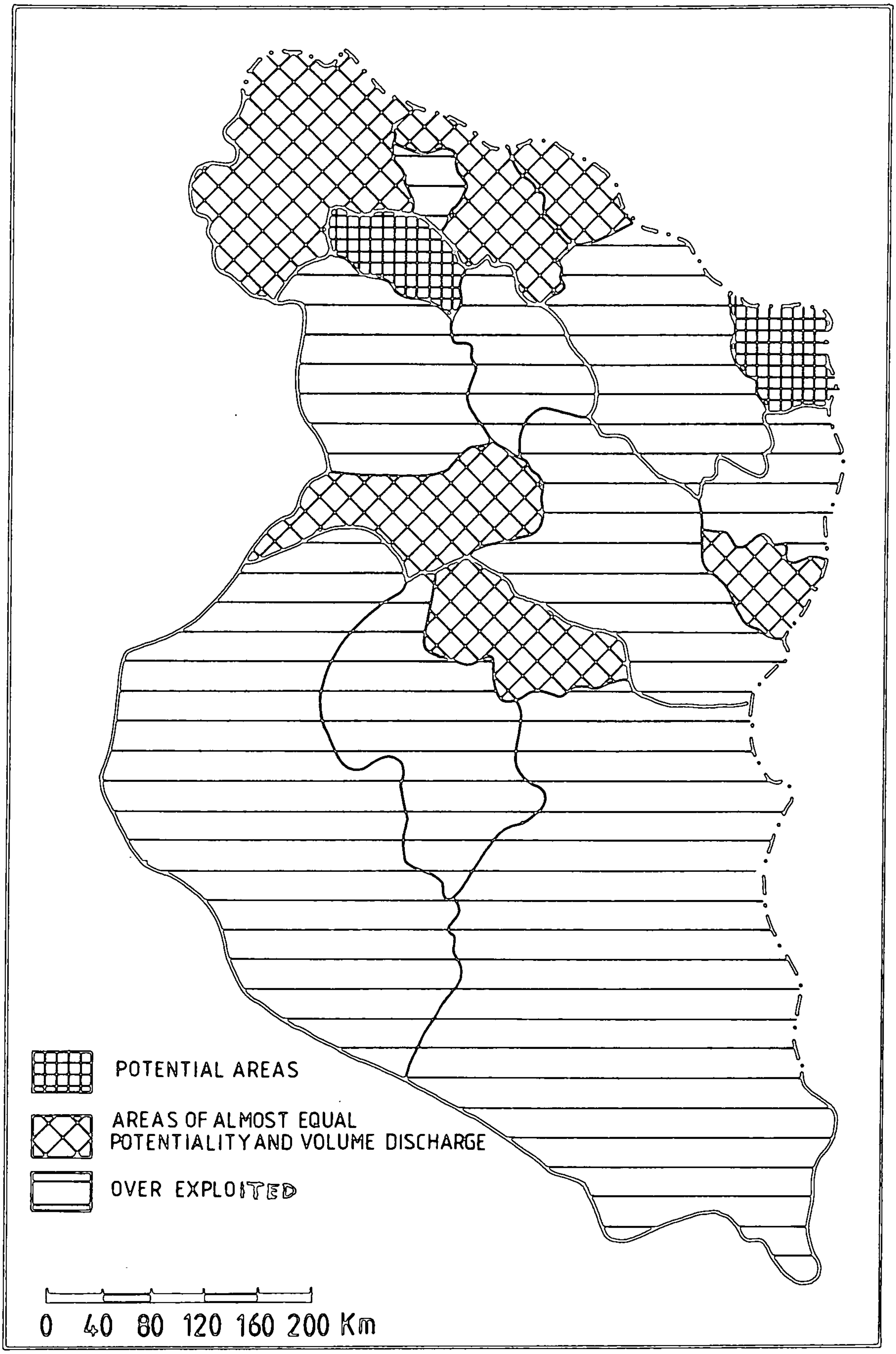


Figure 5.14 Distribution of groundwater potentiality in Khorasan (various sources).

water potentiality. In the south the groundwater potentiality is limited and distributed mainly in the eastern parts, around Qaen, Gonabad Ferdows and Birjand.

Over-exploitation of groundwater resources: By comparing the figures given for the total potentiality (Table 5.9) and that of total discharge (Table 5.8) it is revealed that the region as a whole has overdrawn water by about 1,000 million m^3 per annum. This total is distributed between the north 25.5 per cent, central 61 per cent and south 13.5 per cent.

From a more detailed examination of data (Figure 5.14) it is clear that only in limited areas of Khorasan namely Sarakhs in the north and Esfarayen plain in the centre does the annual amount of potentiality exceed the total volume of discharge. In Bojnurd, Quchan, Dargoz, Bakhezr and Kashmar and Gonabad plains there is almost a balance between potentiality and discharge; while the remaining plains have already seen their groundwater resources overdrawn. More serious examples of this latter group is the heavily populated and cultivated plain of Mashhad in the north. Here, approximately 217 million m^3 extra recharge is needed to level the amount of its total annual discharge. This remarkable overdraw, as has been already explained, is partly due to heavy exploitation of groundwater resources by wells, in an attempt to cope with the regions agricultural need as well as with the growing demand of Mashhad's domestic requirements.

Prior to 1970 Mashhad's water supply was dependent on local qanats and some 14 deep wells constructed within the town and in Qasem-Abad 12 km north west of Mashhad. By 1970, Mashhad's population had risen to approximately 500 thousand and the total water discharge obtained by the above mentioned wells was insufficient to cope with the growing demand. Therefore, during 1970-71, the construction of an (artesian) well and another ten deep wells in Manzel-Abad, near Mashhad were completed with a total discharge capacity of 1100 litres per second. However, with the further increase of population and thus water demand, the decision was made for the construction of storage dams on the river Toroq and Kardeh.

The noticeable high rate of overdraw in some of the central basins of Khorasan namely Neyshabur, Torbat-e-Jam and Torbat-e-Heydariyeh can be explained partly by the construction of many wells, and partly due to the extra consumption of water in irrigation to flush the accumulation of the salts in these plains.

Groundwater quality : It can be stated in general that the quality of the groundwater in Khorasan region declines from north to south and from the upland parts to lower parts of the plains. In the northern plains of Khorasan the quality is good to fair. Bojnurd, Mashhad (excluding the eastern parts), upper plains adjacent to mountains and the areas where groundwater is directly influenced by the river's infiltration, such as eastern areas of Sarakhs, northern Dargaz, Quehan and Shirvan plains have almost no limitation in terms of chemical quality of the groundwater resources. Nowhere in these areas does the chloride content of the groundwater and the amount of electrical conductivity, exceed 250 mg/l and 500 micromhos/cm respectively. Relatively poor quality areas in which the amount of chloride in the water is higher than 250 mg/l (between 250 and 1500 mg/l) are the eastern parts of Mashhad, central areas of Quchan plain, and south and south western parts of Dargaz. The poor quality of the groundwater in these areas is mainly caused by the presence of Miocene marls alternating with gypsum, which forms the tuff of the plains. Although water with this amount of chloride will have a somewhat salty taste in terms of agricultural use it does not present any serious problems (water with the amount of 3500 mg/l chloride can still be possible used for irrigation).

The average amount of chloride and the electrical conductivity of the groundwater to a large extent increases in the central basins of Khorasan. The best quality groundwater in basins occurs in the head of the alluvial fan, where the electrical conductivity of the water is lower than 500 micromhos/cm. Towards the central areas of the basins the amount of both chloride and the electrial conductivity increase remarkably, partly due to the existance of formations which contain thick beds of evaporates and in most parts are gypsiferous and saliferous, and partly due to the presence of the water table close to the surface. The salinity of the groundwater is particularly high in the areas situated along the river Kal-e-Sur which runs through the centre of the Neyshabur and Sabzevar basins. The amount of chloride and the electrical conductivity in this area is the highest in the province reaching to a maximum 5000 mg/l and 12000 micromhos/cm.

Similar to the central areas of Khorasan, in the southern areas of Khorasan the quality of groundwater varies greatly from upper parts to lower parts of the plains. In the upper parts the amount of chloride and the electrial conductivity are low (generall less than 100 mg/l and 500 micromhos/cm). As groundwater processes along its natural course towards the lower parts of the plains the amount of chloride in the water increases and finally in the central basins, or in the lowest parts of the plains, the amount of chloride increases highly and the water contains so much chloride that in some areas the water becomes totally unusable for drinking and farming. Here the amount of chloride and electrical conductivity can reach to 2000 mg/l and 9000 micromhos/cm.

The importance of water supplies in explaining settlement location is clear to see, but to consider it to be the only factor is to be blinded of other influencing determinants. At this stage it is useful to step back to consider settlement patterns *per se* and then to examine land use and population factors as additional possible explanations of these patterns.

CHAPTER 6 : SETTLEMENT PATTERNS, SIZE AND SPACING

PATTERNS

In Khorasan, as with other arid regions of Iran, the location and pattern of the villages appears to be strongly influenced by water. It has been noted that whilst surface water configuration has its greatest effect in upland areas, in lowlands a more decisive role in shaping the pattern of the settlements is played by the geographical distribution of ground water resources such as springs, wells and qanats. The important role of water supply in the location of settlements was evident in the relationship between these two variables, which was described in Chapters 4 and 5. Nevertheless, combined with the influences of physiography and land productivity it is possible to distinguish three distinct types of settlement patterns in the region : linear, clustered and scattered.

Linear patterns : A good example of this type of settlement pattern is seen along the approximate 200 miles length of the Atrak-Kashaf valley in the north. Here, the tendency towards the linear shape is particularly marked along that part of the valley which passes through the fertile intermontane plains of Bojnurd, Shirvan, Quchan and Mashhad. As can be seen from Figure 6.2, in some parts of the valley where the soils are more fertile and there is good quality and quantity of ground water available to supplement the shortage of river water for intense irrigation farming (i.e. the area along the river Kashaf to the west of Mashhad), one finds the most densely and compact forms of linear settlements in the region, and indeed one of the best examples of such a pattern in the country as a whole. By contrast in parts of the valley

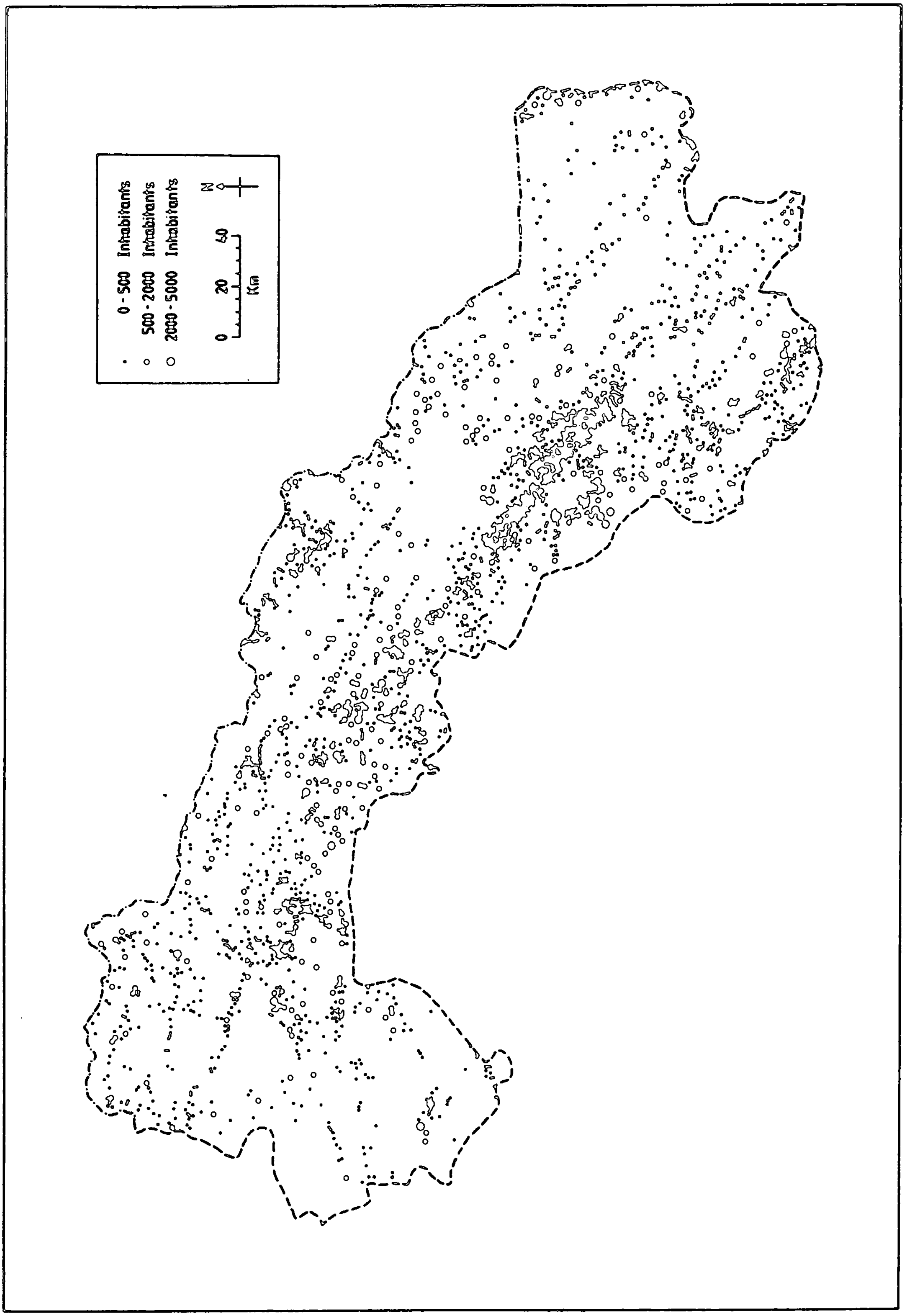


Figure 6.1 Villages in north Khorasan - 1966.

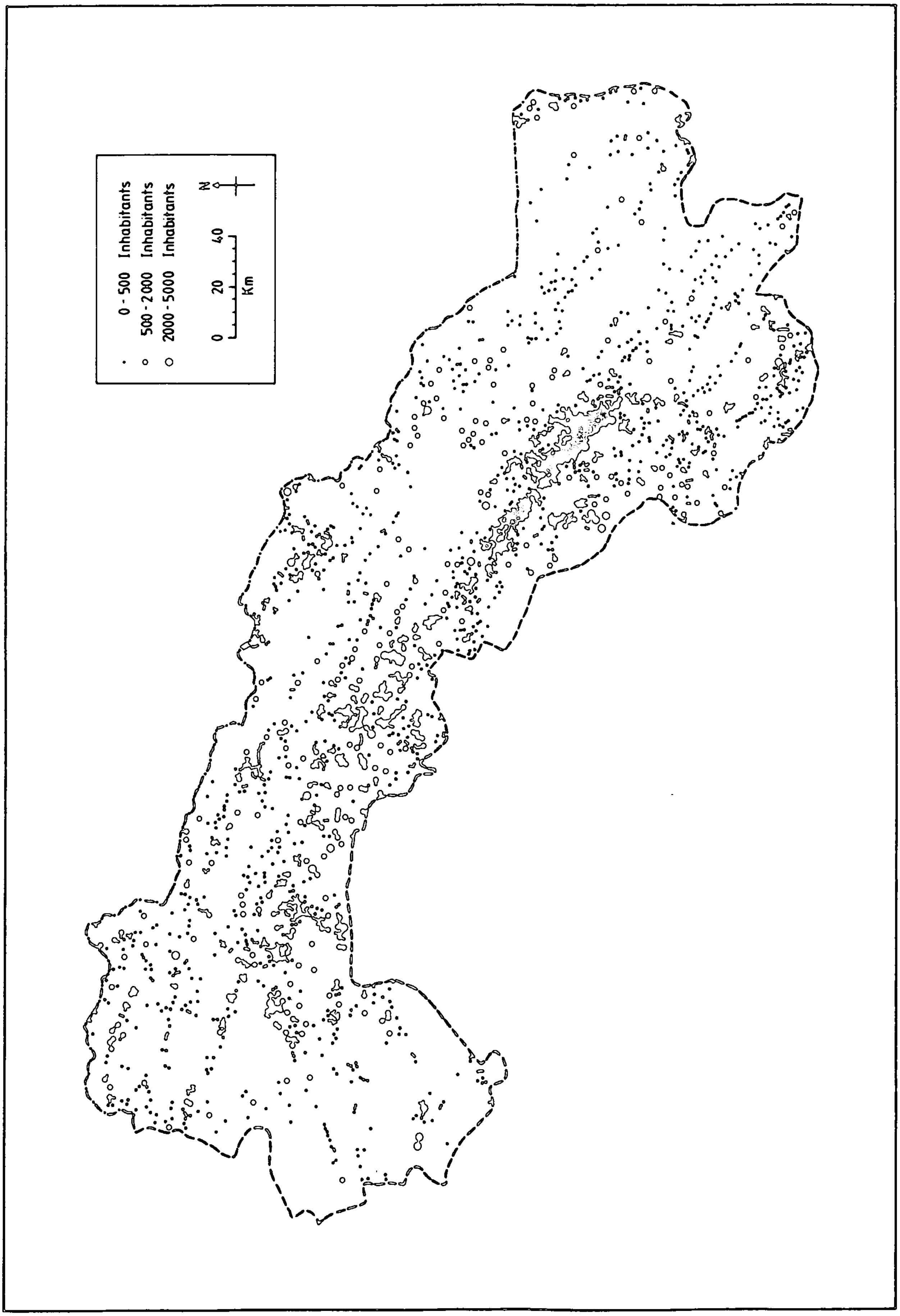


Figure 6.2 Villages in north Khorasan - 1976.

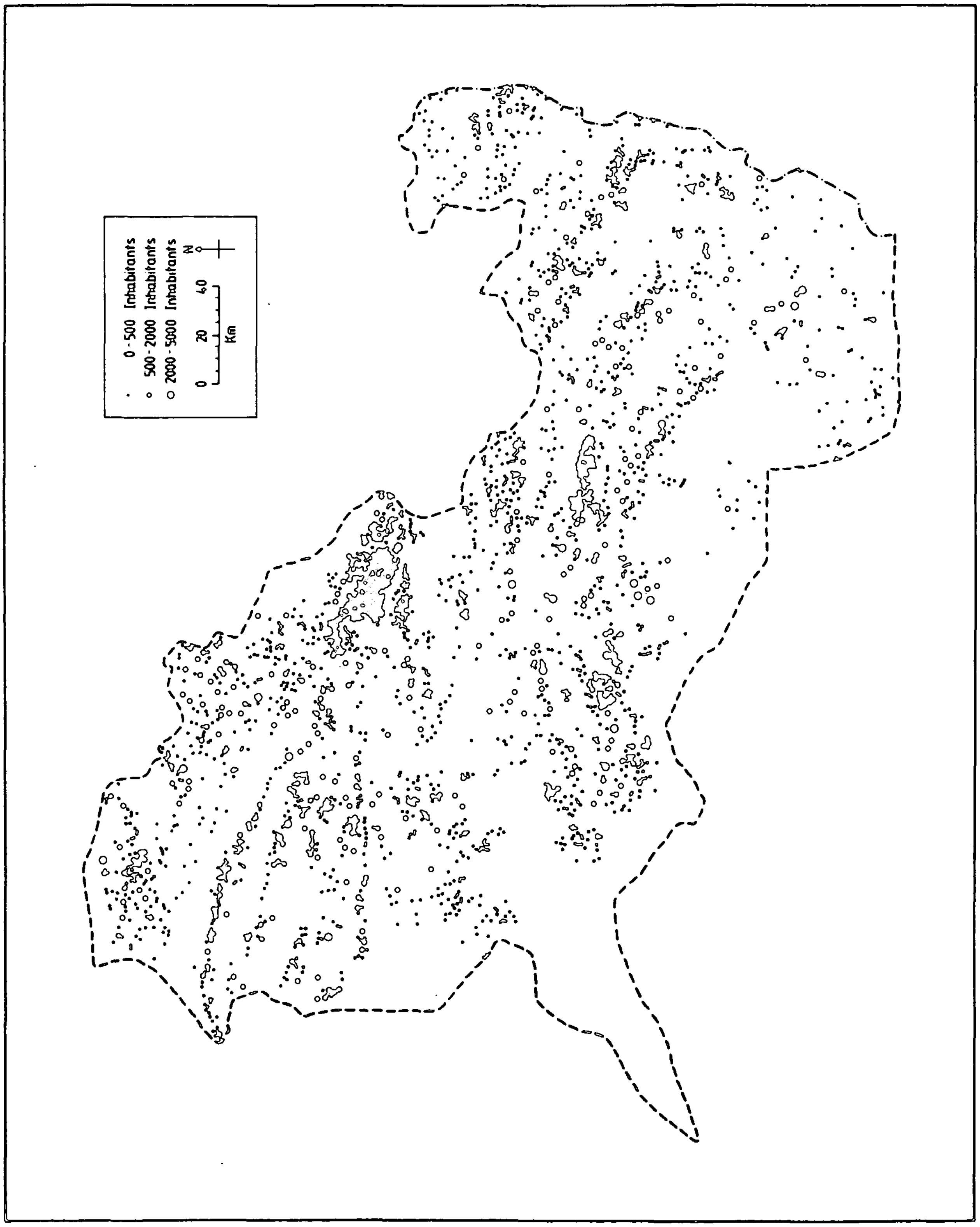


Figure 6.3 Villages in central Khorasan - 1966.

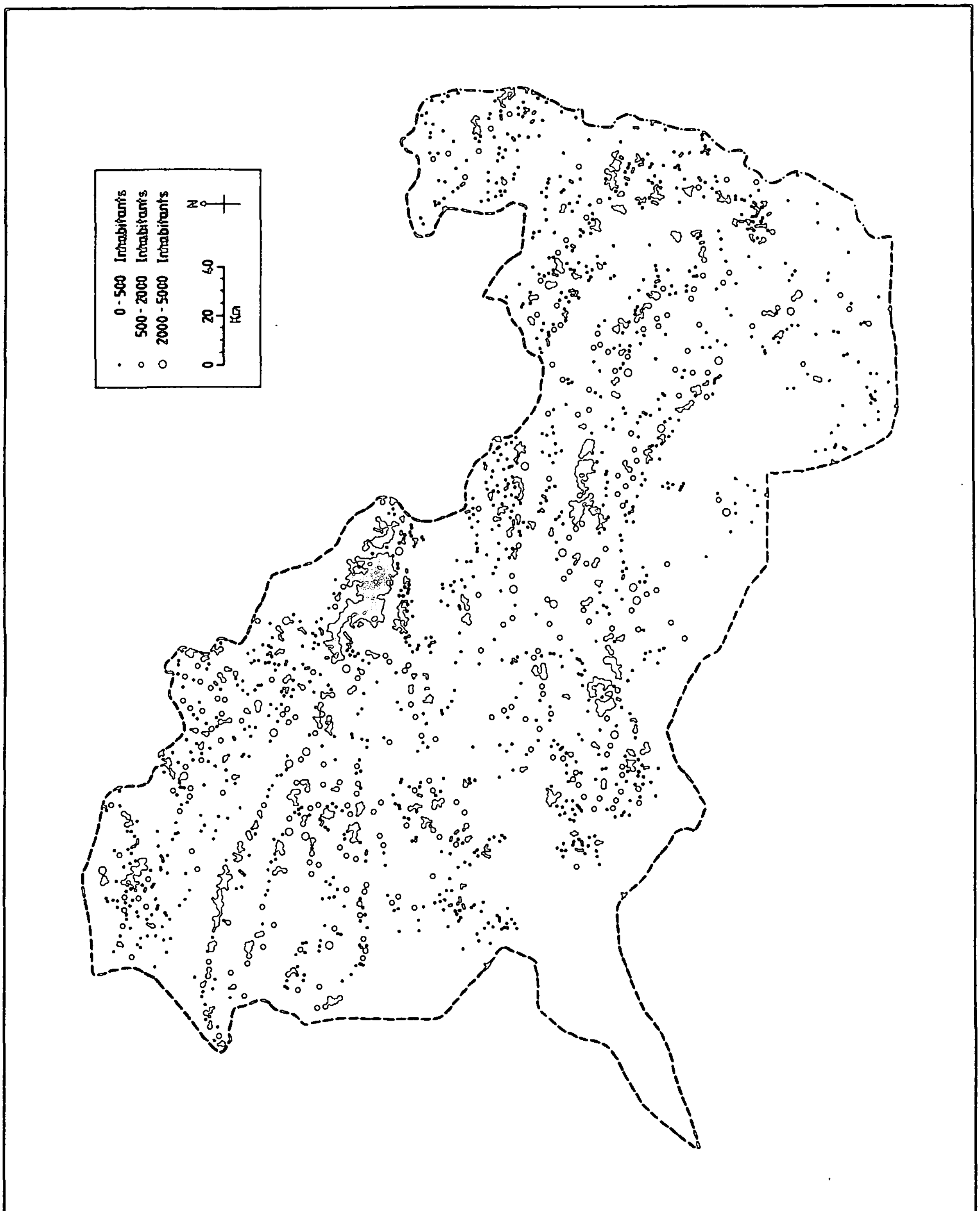


Figure 6.4 Villages in central Khorasan - 1976.

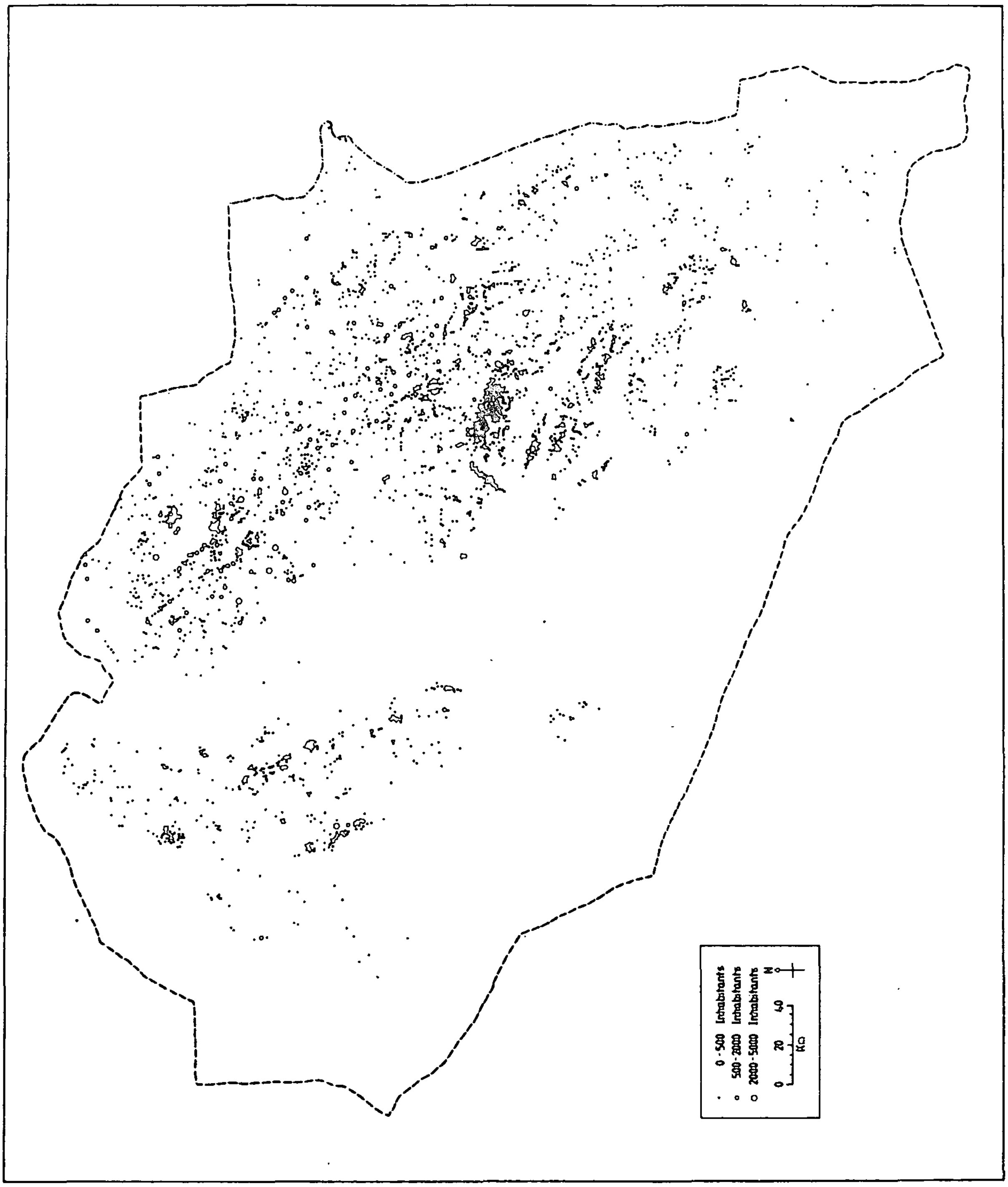


Figure 6.5 Villages in south Khorasan - 1966.

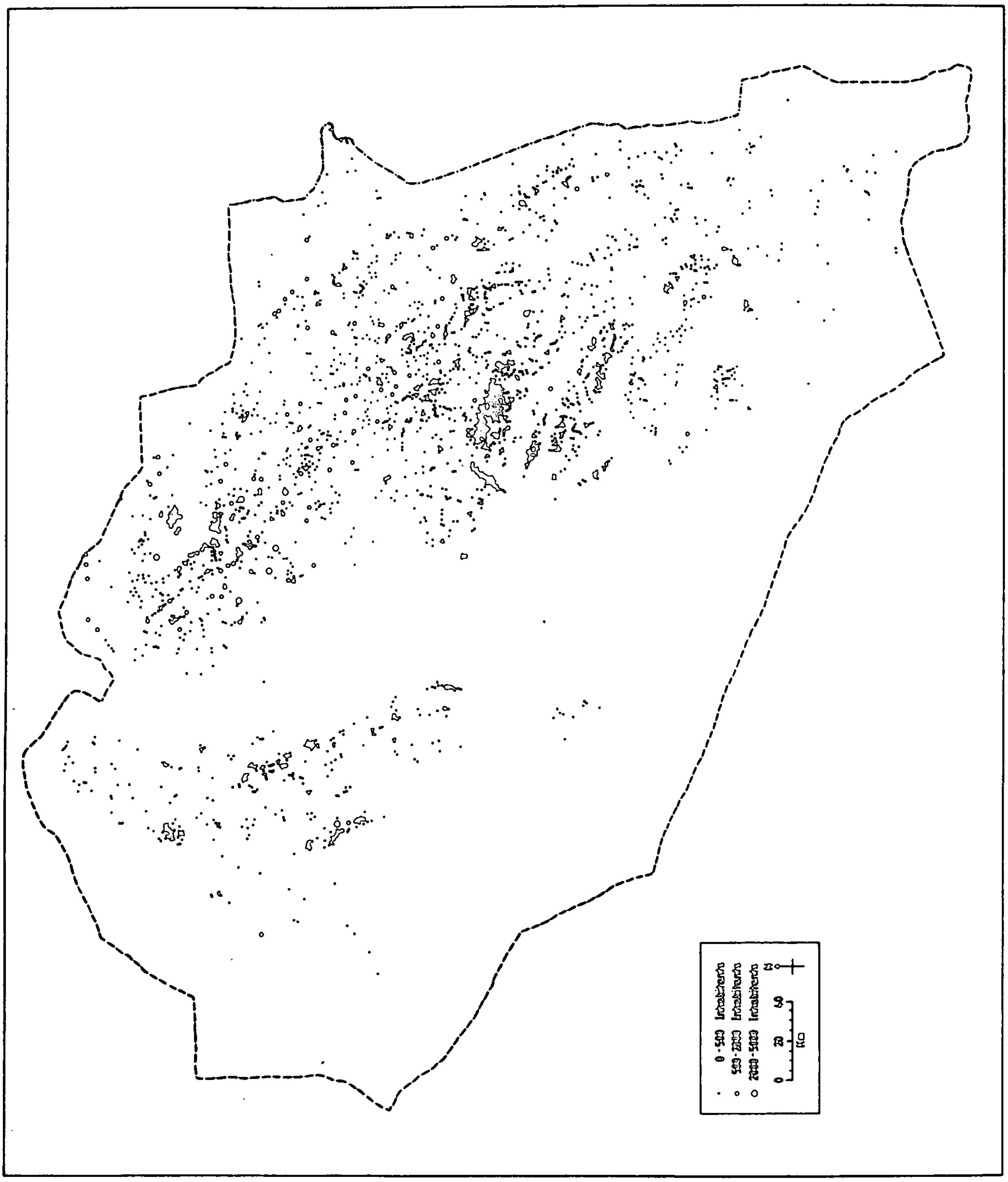


Figure 6.6 Villages in south Khorasan - 1976.

where the potentiality of the soils is low and ground water resources insufficient for intense irrigation (for example, along riverain banks of the Kashaf to the east of Mashhad and along the northern bank of the Atrak to the west of Bojnurd) the linear pattern is less evident. Linear shaped, but widely spaced, villages are also found along the River Tajan in Sarakhs bordering the USSR and along the more developed upland river valleys which are well suited and famous for the production of fruit (such as those at Shirin Dareh, Chanaran, Golmakan, and Zoshk).

Towards the south of Khorasan where the importance of the rivers as a source of water supply is greatly decreased, there is less tendency for linear shaped settlements to exist. In fact the only compact linear patterns which are found outside the northern areas of Khorasan are formed alongside the Mashhad-Tehran railway, south of Esfarayen. Here, the restricted fertile land which is found in narrow stretches along the river Jovain and the availability of considerable groundwater resources for irrigation are the main factors contributing to the compact linear pattern in the area.

Clustered patterns : This type of settlement pattern is more predominant in the central areas of Khorasan. As explained previously this part of Khorasan is formed by a number of poorly drained basins. The lower parts of these basins are generally covered by soils which suffer greatly from aridity, salinity and erosion. As a result, a great majority of the settlements are concentrated in the upper parts of the basins where these limiting factors are somewhat reduced. The most compact clustered patterns are formed on the patches of good fertile land which are situated on the alluvial fans and therefore have the advantage of surface water descending from the nearby mountains. The largest and the most fertile of these patches of agricultural lands are formed along the southern flanks of Binalud (Neyshabur, and Esfarayen plains), and along the southern flanks of Kuh-e-Surkh (Torbat-e-Haydaryeh and Kashmar plains). These plains are isolated from each other by the relief structure, desert and by the spatial distribution of groundwater resources, and thus patches of compact clustered settlement forms are found in the area (See Figure 6.4). However, the clustered pattern of settlements in these plains is not determined only by the quality of the land but also by the geographical location of underground water resources such as via qanats and wells, on which the existence of agriculture depends.

Scattered patterns: The scattered types of settlement pattern are found in many parts of Khorasan, notably in the low rainfall upland areas and parts of the lowlands where a shortage of rainfall and groundwater availability have restricted the amount of arable land. From the analysis of general maps of settlement distribution (Figures 6.2, 6.4 and 6.6) it is possible to conclude that the most scattered pattern of settlement distribution is found in the marginal desert areas particularly in the south around Tabas, Ferdows and the Southern areas of Birjand Shahrestan. Elsewhere a more clear form of scattered pattern is found in the Sarakhs lowland and the south western areas of Bojnurd Shahrestan (in the north), Southern areas of Torbat-e-Heydariyeh and the marginal desert areas to the west of Sabsevar Shahrestans (in the Central region).

CHANGE IN THE DISTRIBUTION OF SETTLEMENTS (1966-1976)

From the comparison of the maps of settlement distribution in 1976 (Figures 6.2, 6.4 and 6.6) and that of 1966 (Figures 6.1, 6.3 and 6.5), it becomes apparent that there has been no major change in the pattern of settlement distribution during the 1966 and 1976 period. However, in the areas where there has been an adequate increase in groundwater potentiality, such as in the Neyshabur, Torbat-e-Jam and Bakhezr plains, as a result of construction of many wells, a considerable number of new settlements appeared in these areas. Figure 6.4 shows the affected areas in Torbat-e-Jam and Bakhezr regions. As can be seen by the construction of many wells during the 1966-1976 period some sort of clustered type of patterns formed in these areas.

DENSITY AND SIZE

As can be seen from Figures 6.2, 6.4 and 6.6 the rural settlements are unevenly distributed over the region. The more densely settled areas of Mashhad and Neyshabur plains contrast with the extensive desert land areas of the South where it is almost devoid of permanently settled villages.

The total area, number of settlements and density, as well as the rank of each main and sub-divided area of Khorasan, are shown in Table 6.1. The general density (number of settlements divided by the total land area) for the region as a whole is very low, only 2.6 villages per 100 km^2. The corresponding figures for the main divisions of north, central and south (4.4, 3.2 and 1.6 respectively) demonstrate a decreasing trend in the density towards the south, reflecting the availability of water resources and usable land in these areas.

Table 6.1 Settlement density by region

Region	Area in sq.km	Total settlements	Settlement density per 100 sq. km	Rank: Area	Rank: Settlements	Rank: Density
Mashhad	27,487	1,315	4.8	3	2	4
Bojnurd	17,200	582	3.4	7	4	7
Quchan	6,868	404	5.9	12	7	2
Shirvan	2,279	113	5.0	16	16	3
Dargaz	4,687	159	3.4	15	15	7
Total North	58,521	2,573	4.4	-	-	-
Neyshabur	9,308	680	7.3	9	3	1
Sabzevar	19,651	482	2.6	6	6	8
Torbat-e-Jam	8,362	311	3.7	11	8	6
Bakhezr	5,084	227	4.5	14	13	5
Torbat-e-Heydariyeh	23,888	571	2.4	4	5	9
Kashmar	13,285	263	2.0	8	10	10
Esfarayen	5,345	182	3.4	13	14	7
Total Central	84,923	2,716	3.2	-	-	-
Birjand	83,425	1,999	2.4	1	1	9
Ferdows	22,009	233	1.1	5	11	11
Gonabad	8,999	230	2.6	10	12	8
Tabas	55,460	265	0.5	2	9	12
Total South	169,893	2,727	1.6	-	-	-
Khorasan	313,337	8,016	2.6	-	-	-

The general settlement densities range from the highest 7.3 in Neyshabur to the lowest 0.5 per 100 km² in Tabas Shahrestan. Mashhad, Bojnurd, Qushan, Shirvan, Dargaz in the north, Neyshabur,, Torbat-e-Jam, Bakhezr,, and Esfarayen in the centre have a density value higher than the average for Khorasan. In Sabsavar the density value equals the regional average and in the remaining shahrestans of Torbat-e-Haydariyeh and Kahmar in the centre and Birjand, Tabas, Ferrows and Gonabad in the south the general density value is lower than that of the region as a whole (see Table 6.1). The density value is particularly low in the southern shahrestans of Tabas and Ferdows where, for example, with 493 settled villages, that is nearly half the number in the single Neyshabur shahrestan, they account for a total land area of 77,469 km² which is 113 times greater. One obvious explanation for such a disproportion is the fact that a large area of the shahrestans in the South are occupied by deserts and thus are not favourable sites for settlement.

Settlement density : On the basis of the analysis of the sample spacing data (see later sections), it can be said that similar discrepancies to the region as a whole also exist in upland and lowland areas. Neyshabur with an average spacing value of 5.1 km and Quchan with an average spacing value of 3.8 km are the most densely settled shahrestans in upland and lowland areas respectively. By contrast, Tabas shahrestan in the south with an average spacing of 13 km and 14.4 km is considered to be the most dispersed settled shahrestan of Khorasan in upland and lowland areas respectively.

Rural settlement size in Khorasan : Table 6.2 gives the number and percentage of the rural population of Khorasan province living in

	– 100		100 - 250		250 - 500		500 - 1000		1000 - 2000		2000 - 5000		Total	
Dargaz	65	2,327	48	8,556	33	11,504	9	6,712	1	1,062	31	7,784	159	37,945
Mashhad	612	23,158	312	49,147	193	68,792	134	91,934	40	57,909	24	60,461	1,315	351,401
Quchan	105	4,799	89	14,495	101	37,008	84	58,303	18	20,471	7	21,867	404	156,943
Shirvan	42	1,538	19	3,446	22	7,391	23	16,625	5	7,396	2	5,251	113	41,647
Bojnurd	246	8,071	113	19,440	107	36,850	81	57,513	27	36,459	8	22,183	582	180,516
Total North	1,070	39,893	581	95,084	456	161,545	331	231,087	91	123,297	44	117,546	2,573	768,452
Torbat-e-Jam	107	5,775	105	17,588	62	21,581	25	17,902	11	17,338	1	2,321	311	82,505
Torbat-e-Hey dariyeh	191	7,943	140	22,404	111	39,145	77	52,032	38	53,606	14	38,803	571	213,933
Bakhezr	119	4,624	41	6,614	36	12,443	21	13,971	8	11,612	2	5,083	227	54,347
Kashmar	126	3,093	26	4,519	27	9,640	42	28,279	36	49,409	6	20,543	263	115,483
Esfarayen	51	2,698	53	9,062	40	13,809	29	20,634	7	9,158	2	6,899	182	62,260
Sabzevar	178	5,823	64	10,454	96	34,372	103	70,635	34	43,641	7	17,817	482	182,742
Neyshabur	236	10,647	204	33,089	127	44,078	83	56,071	23	31,458	7	16,332	680	191,675
Total Central	1,008	40,603	633	103,730	499	175,068	380	259,524	157	216,222	39	107,798	2,716	902,945
Gonabad	153	4,280	32	4,943	12	4,345	16	12,138	13	16,524	4	12,249	230	54,479
Tabas	211	6,731	33	5,267	12	4,786	6	3,343	2	2,488	1	2,030	265	24,645
Ferdows	175	2,653	21	3,478	17	6,050	10	6,847	6	7,609	4	13,705	233	40,342
Birjand	1,456	44,273	329	52,334	125	44,531	66	42,777	18	23,574	5	11,452	1,999	218,941
Total South	1,995	57,937	415	66,022	166	59,712	98	65,105	39	50,195	14	39,436	2,727	338,407
Total Khorasan	4,073	138,433	1,629	264,836	1,121	396,325	809	555,716	287	389,714	97	264,780	8,016	2,009,804

Table 6.2 Number and percentage of rural population in each of the three main sub-divisions.

villages of different sizes in the three main divisions, 16 sub-divided areas, and for the province as a whole in 1976. One main feature shown in this Table is the small population sizes in many of the villages, for example 6,812, or more than 84 per cent, of the rural settlements of Khorasan have less than 1,000 inhabitants. The extremely small villages, those with less than 250 inhabitants, constitute more than 60 per cent of the total rural settlements. In other words, 403,269 or about 20 per cent of the total rural population are scattered among 4,882 or more than 60 per cent of the total number of villages. This small demographic size of the villages has been one of the major obstacles to the overall development of rural areas in the region. The relationships between the small population sizes of the villages and the establishment of various services is examined elsewhere in this thesis, but here it is worth noting how the accessibility to services varies according to settlement size. The smaller the population of villages, the more restricted is access to different services such as communications, schools, clinics and baths.

Among the factors causing the overall small populations of the villages, water supplies seem to be the most critical. Wherever there is water for irrigation, almost regardless of how limited, population tends to gather. Nevertheless, as was explained in Chapters 4 and 5 the quality, quantity and importance of water supplies are not uniform throughout the region and the sizes of villages varies accordingly. In the following section these variations are examined further in the context of upland and lowland areas, as well as in the major and sub-divided areas of the region.

Settlement size and its distribution in upland areas : The highly seasonal water supply, associated with obstacles of topography and land factors such as dissected valleys, steep sloping and rugged land surfaces are the main factors which restrict village growth and account for the scattered distribution of agricultural lands and settlement in upland areas. On the basis of the 1976 Village Gazetteer 799,981 or 47.3 per cent of the total rural population of Khorasan were housed in 3,791 upland villages. This means a small average size of about 211 persons per village. As also shown in Table 6.2, the small demographic size of the villages are particularly more pronounced in the southern areas. From a total of 1,802 settled villages in the south in 1976, only 21 had a population over 1,000 inhabitants, much fewer than those in the north and central divisions. As a result the average population size of upland villages in this part of Khorasan falls much lower than the other two divisions being 101.2 against 326.9 and 298.3 in central and northern areas respectively.

Among the sub-divided areas of the province the average size of upland villages ranges from the highest of 483.9 and 388.3 respectively in Bakhezr and Neyshabur in Central Khorasan to as low as 92.6 and 119 respectively in Birjand and Gonabad shahrestans in the south (see Table 6.2).

Settlement size and its distribution in lowland areas : Unlike the case in the uplands, lowland villages have the advantage of greater availability of flat fertile land and the utilization of the groundwater resources, and therefore in comparison with the upland villages of

Shahrestans	Upland areas					Lowland areas				
	Total Number of villages	Total population	Average size of village	No.of villages with populations of more than 1000 inhabitants	Total population	Total Number of villages	Total population	Average size of village	No.of villages with populations of more than 1000 inhabitants	Total population
Mashhad	463	125,588	271.2	29	44,328	852	225,813	265	35	74,042
Quchan	250	86,443	345.8	12	16,242	154	70,500	457.8	13	26,096
Shirvan	57	20,820	365.3	2	2,875	56	20,827	371.9	5	9,772
Bojnurd	329	99,613	302.8	18	24,796	253	80,903	319.8	17	33,846
Dargaz	45	8,797	195.5	1	1,062	114	29,148	255.7	3	7,784
Total North	1,144	341,261	298.3	62	89,303	1,429	427,191	298.9	73	151,540
Neyshabur	168	65,227	388.3	15	25,321	512	126,448	247	15	22,469
Torbat-e-Jam	105	21,314	195.5	2	3,353	202	61,191	303	10	16,306
Bakhezr	35	1,693,717	483.9	4	6,217	192	37,410	194.8	6	10,478
Torbat-e-Heydariyeh	152	526	346.2	11	21,425	419	161,316	41	41	70,984
Sabzevar	215	65,877	306.4	12	16,381	267	116,865	437.7	29	45,077
Esfarayen	73	26,503	285.0	5	7,213	109	35,757	328	4	8,844
Kashmar	93	27,797	298.9	11	15,786	170	87,686	515.8	31	54,166
Total Central	845	276,272	326.9	60	95,696	1,871	626,673	324.9	136	228,324
Birjand	1,464	135,637	92.6	12	15,874	535	83,304	155.7	11	19,152
Ferdows	104	13,515	129.9	2	3,378	129	26,827	208	8	17,936
Tabas	112	18,772	167.6	3	4,518	153	5,873	38.4	-	-
Gonabad	122	14,524	119.0	4	4,918	108	39,955	37.0	13	23,855
Total South	1,802	182,448	101.2	21	28,688	925	155,959	168.6	32	60,943
Khorasan	3,791	799,981	211	143	213,687	4,225	1,209,823	286.3	241	440,807

Table 6.3 Contrasting village characteristics according to altitude in each of the main sub-divisions.

Khorasan they are generally larger both in number and size of population. According to the Village Gazetteer of Khorasan (1976), of the total of 8,016 villages in Khorasan, 4,225 or about 52.7 per cent were located in lowland areas. Considering the 1,209,823 people living in these villages, the average for the lowland areas comes to a figure of 286.3 persons per village which is noticeably higher than that of 211 in the upland villages. However, since availability of the above mentioned favourable factors are more pronounced in the north and central areas of Khorasan, the average size of the lowland villages in these areas is higher than the provincial figure, being 298.9 and 324.9 respectively. This compares with an average of 286.3 for the region as a whole. By contrast, in the southern areas, the insufficiency of rainfall (generally less than 200 mm per annum), together with the low productivity of the land, and the poor supply of qanat water for irrigation, have led to the formation of some villages with very small populations. As shown in Table 6.3, only 32 out of 925 inhabited settlements in the lowland areas had a population of over 1,000 in 1976. As a result the average size value of the lowland villages in the south falls to 168.6 persons which is far below that of the average for the province as a whole.

Table 6.3 also indicates noticeable differences among the sub-divided areas. For example, the average size of lowland villages in Kashmar shahrestan in central Khorasan was 13 times greater than the average for Tabas and Gonabad shahrestans in the south. All together, eight shahrestans had an average size below the regional level in 1976. These were : Dargaz and Mashhad in the north, Bakhezr and Neyshabur in the centre and all shahrestans of southern Khorasan, namely Birjand

Gonabad, Ferdows and Tabas. As can be seen from Table 6.3, the average settlement size is particularly low in southern shahrestans where farming is largely dependent on small precipitation amounts or from river sources. Groundwater supplies are generally too small to allow largescale irrigation farming. In the remaining shahrestans of Mashhad, Bakhezr, Dargaz and Neyshabur, although the average size of the villages is smaller than the province, because of more favourable conditions of water supplies for irrigation, the gap is not great. One noticeable reason which might be given for their lower level of average village size compared with the province is that in these areas there are numerous cases where a settled place is not actually a 'village' but only a small hamlet (with a few people - usually less than 10) formed either as a 'Kalateh' (farm houses), or for keeping and maintaining the deep and semi-deep wells which are usually constructed in the fields away from the village. This latter case is seen particularly in the district of Fariman (southeast of Mashhad shahrestan), and in Bakhezr lowland areas.

Village size variation in the main and sub-divided areas : In arid regions of Khorasan where the lack of water is a severe limiting factor for agricultural activity, the actual location and size of the villages are determined primarily by the size and the importance of surface and groundwater resources, and the techniques of obtaining them for irrigation, such as surface canals, qanats and wells. However, as was explained in Chapters 4 and 5, the provision of water resources and the number of water supply outlets varies remarkably between the south and the other two divisions. For example, in southern areas of Khorasan, despite the fact that its number of inhabited villages is higher than that of the north and the centre, its proportional share of water is much smaller. In the south, not only are the qanats' discharge comparatively smaller, but also there are many cases where a single qanat supplies more than one village. This is evident from the fact that in 1976, its total 1,406 number of water supply (qanats, wells and springs) points were about half the total (2,727) number of villages in the area. This is, however, a clear indication that the agricultural activities in this part of Khorasan is largely dependent on dry farming and thus resulting in both the cultivated lands and villages being generally smaller because of the fact that the productivity of dry farming is uncertain and considerably less than that of irrigated areas. In the case of wheat production for example yields averaged 289 kg/ha compared with 896 kg/ha in irrigated areas (see Chapter 8).

As shown in Table 6.2, of the total 2,727 villages in the south only 53 or 1.9 per cent had a population of 1,000 or more, while the extremely small villages with a population of less than 100 constituted 1,995 or 73 per cent of its total inhabited rural settlements.

Unlike the situation in the south, in the north and central areas of Khorasan the number of water supply points exceed the total number of villages by nearly 20 per cent (being 6,565 and 5,289 respectively). Knowing the fact that qanats and wells are commonly used in the lowland areas, then it is reasonable to assume that each lowland village in the north and central areas of Khorasan has an average of about two water supply points (usually a qanat and a well). It is therefore not surprising that a great majority of large villages of Khorasan are found in the northern and central division. They constitute 35.2 and 51 per cent respectively of the total 384 large villages (villages with a population of over 1,000 inhabitants) of Khorasan. As a result the average size of villages in these two areas is remarkably higher than the south being 304.3, 331.1 and 153.1 respectively (see Table 6.2). With respect to sub-divided areas the average size varies between the highest 439.1 in Kashmar to as low as 93 in Tabas shahrestan. Dargaz in the north, Bakhezr in the centre and Birjand, Ferdows, Tabas and Gonabad in the south had an average size below the provincial level of 250.7.

Change in the number and size of settlements (1966-1976) : The relatively minor change in the total number of villages during the 1966-1976 period gives the indication that the noticeable decrease of 823 villages during the same period (due to abandonment) must have been compensated and slightly overnumbered by the creation of new settlements. This is however not surprising when considering the remarkable increase in the number of wells in the area (see Chapter 5). This relates mainly to the distribution of new wells in northern and central areas which had an overall increase in the total number of settlements. South of Khorasan there was an overall loss. However, the trend was not the same for all categories of settlement size. As shown by Table 6.4, all major divisions had a net increase in their overall number of large villages (villages with a population of more than 500), only 19 or about 7 per cent of the total increased large villages were distributed in the south. North and central areas shared a much larger proportion, respectively 53 and 38 per cent of the total. In the categories below 500 size villages the trend was different and all major divisions had an overall loss. Of the total loss of 227 villages the north had the lowest proportion (26 or 11 per cent of the total), and the central areas had the highest (130 or 57 per cent of the total).

	- 100			100 - 250			250 - 500			500 - 1000			1000 - 2000			2000 - 50000			Total		
	1966	1976	Change	1966	1976	Change	1966	1976	Change	1966	1976	Change	1966	1976	Change	1966	1976	Change	1966	1976	Change
Mashhad	518	612	+94	390	312	-78	185	193	+ 8	82	134	+52	34	40	+ 6	11	24	+13	1220	1315	+95
Quchan	92	105	+13	101	89	-12	103	101	- 2	74	84	+10	17	18	+ 1	2	7	+ 5	389	404	+15
Shirvan	27	42	+15	15	19	+ 4	26	22	- 4	22	23	+1	2	5	+ 3	2	2	0	94	113	+19
Dargaz	110	65	-45	75	48	-27	41	33	- 8	27	9	-18	7	1	- 6	3	3	0	263	159	-104
Bojnurd	206	246	+40	143	113	-30	101	107	+ 6	56	81	+25	21	27	+ 6	5	8	+ 3	532	582	+50
Total North	953	1070	+117	724	581	-143	456	456	0	261	331	+70	81	91	+10	23	44	+21	2498	2573	+75
Neyshabur	312	236	-76	222	204	-18	121	127	+ 6	53	83	+30	22	23	+ 1	4	7	+ 3	734	680	-54
Sabzevar	153	178	+25	76	64	-12	108	96	-12	78	103	+25	23	34	+11	6	7	+ 1	444	482	+38
Torbat-e-Jam	151	226	+75	150	146	- 4	86	98	+12	36	46	+10	15	19	+ 4	1	3	+ 2	439	538	+99
Torbat-e-Heydariyeh	254	191	-63	162	140	-22	113	111	- 2	64	77	+13	31	38	+ 7	11	14	+ 3	635	571	- 64
Esfarayen	52	51	- 1	55	53	- 2	44	40	- 4	22	29	+ 7	2	7	+ 5	2	2	0	177	182	+ 5
Kashmar	136	126	-10	36	26	-10	39	27	-12	35	42	+ 7	18	36	+18	7	6	- 1	271	263	- 8
Total Central	1058	1008	-50	701	633	-68	511	499	-12	288	380	+92	111	157	+46	31	39	+ 8	2700	2716	+16
Birjand	1480	1456	-24	308	329	+21	132	125	- 7	55	66	+11	15	18	+ 3	3	5	+ 2	1993	1999	+ 6
Gonabad	194	153	-41	24	32	+ 8	10	12	+ 2	19	16	- 3	10	13	+ 3	4	4	0	261	230	-31
Ferdows	175	175	0	23	21	- 2	13	17	+ 4	13	10	- 3	4	6	+ 2	2	4	+ 2	230	233	+ 3
Tabas	239	211	-28	36	33	- 3	13	12	- 1	4	6	+ 2	2	2	0	1	1	0	295	265	-30
Total South	2088	1995	-93	391	415	+24	168	166	- 2	91	98	+ 7	31	39	+ 8	10	14	+ 4	2779	2727	-52
Khorasan	4099	4073	-26	1816	1629	-187	1135	1121	-14	640	809	+169	223	287	+64	64	97	+33	7977	8016	+39

Table 6.4 Changes in village size between 1966 and 1976 for each of the main subdivisions.

The general trend described above is also applicable for the smaller divisions "shahrestans". The only exception is Dargaz shahrestan which as can be seen from Table 6.4 had a loss in all categories. This however can be explained by the fact that a large area of this shahrestan was added to the Mashhad shahrestan in 1976 and hence the boundaries changed.

SETTLEMENT SPACING

Upland areas : The highly seasonal water shortage and the conditions of the land such as steep slopes and ruggedness do not permit spatial aggregation of agricultural activities in upland areas of Khorasan. The small and scattered location of the agricultural activities in these areas has not only resulted in small village populations but also in a greater spacing between villages. According to the analysis of sample data (Figures 6.7, 6.8, 6.9, and Table 6.5), the average spacing of the upland villages for the region as a whole comes to 7.1 km. Although the average spacing value for the main divisions of the north, centre and south of Khorasan has an increasing tendency southwards, the differences are small the average spacing being 6.8, 7.0 and 7.6 km respectively.

In the north, the average spacing value of the upland villages is the lowest in Shirvan (5.8 km) and Quchan (6.4 km), being below the average value calculated for the north (6.8 km) and the province (7.6 km). while the remaining shahrestans of Mashhad, Bojnurd and Dargaz the average distance is higher than the corresponding value for the north and province being 7.2, 7.3, and 7.5 km respectively. The most densely concentrated upland villages of northern Khorasan are found to the south west of Mashhad, where a number of close-distance parallel river valleys

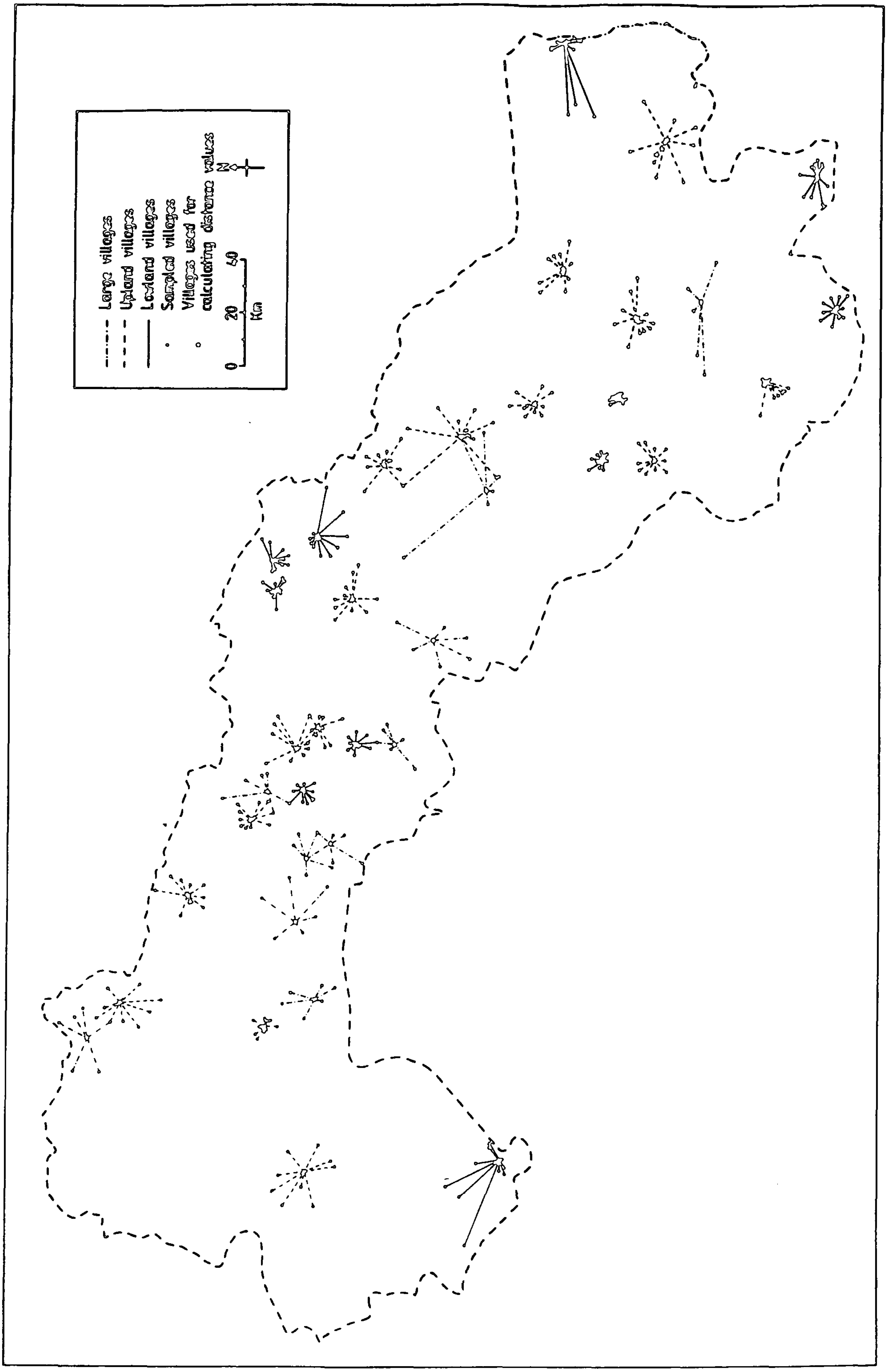


Figure 6.7 Sample average village spacing in north Khorasan.

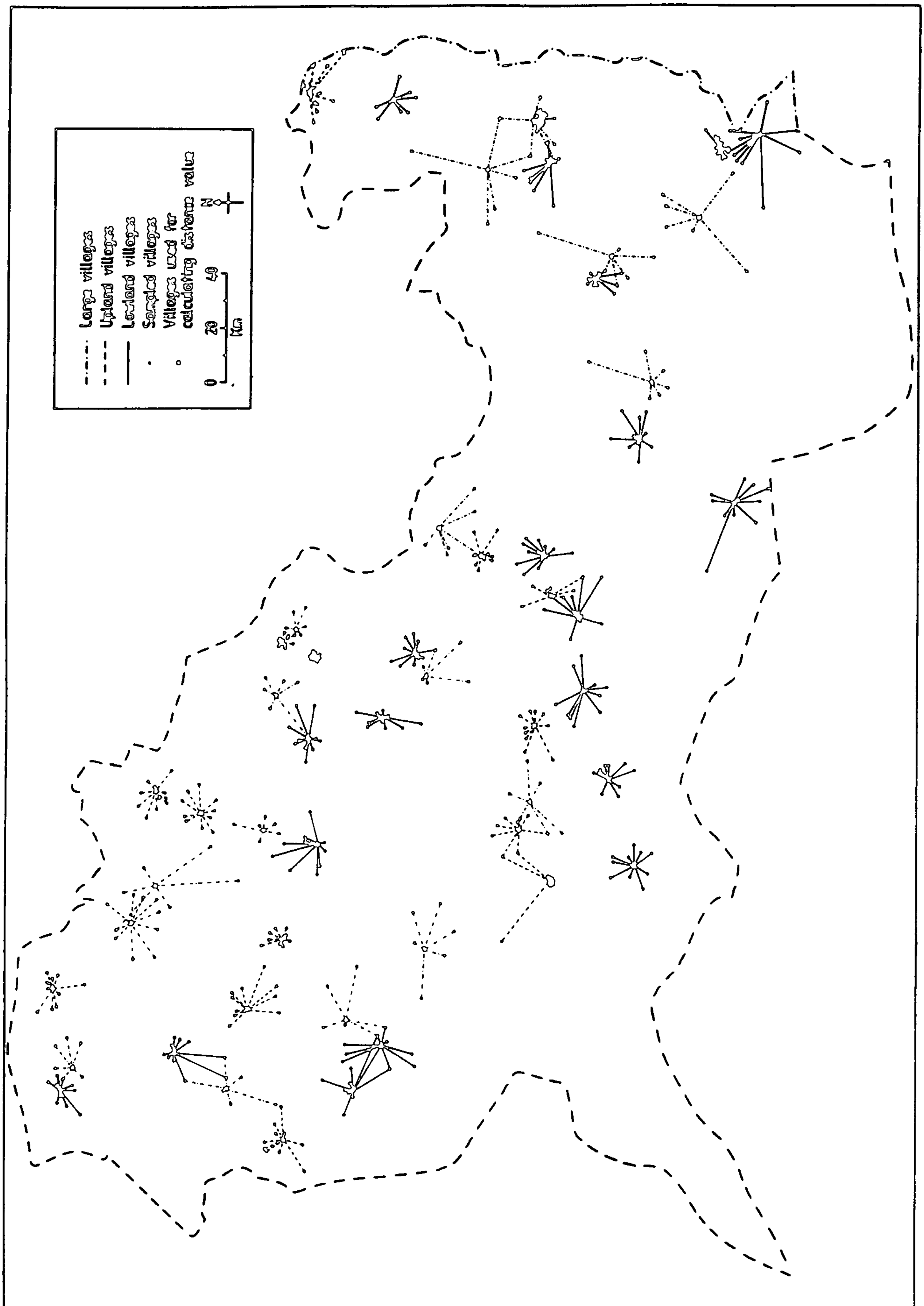


Figure 6.8 Sample average village spacing in central Khorasan.

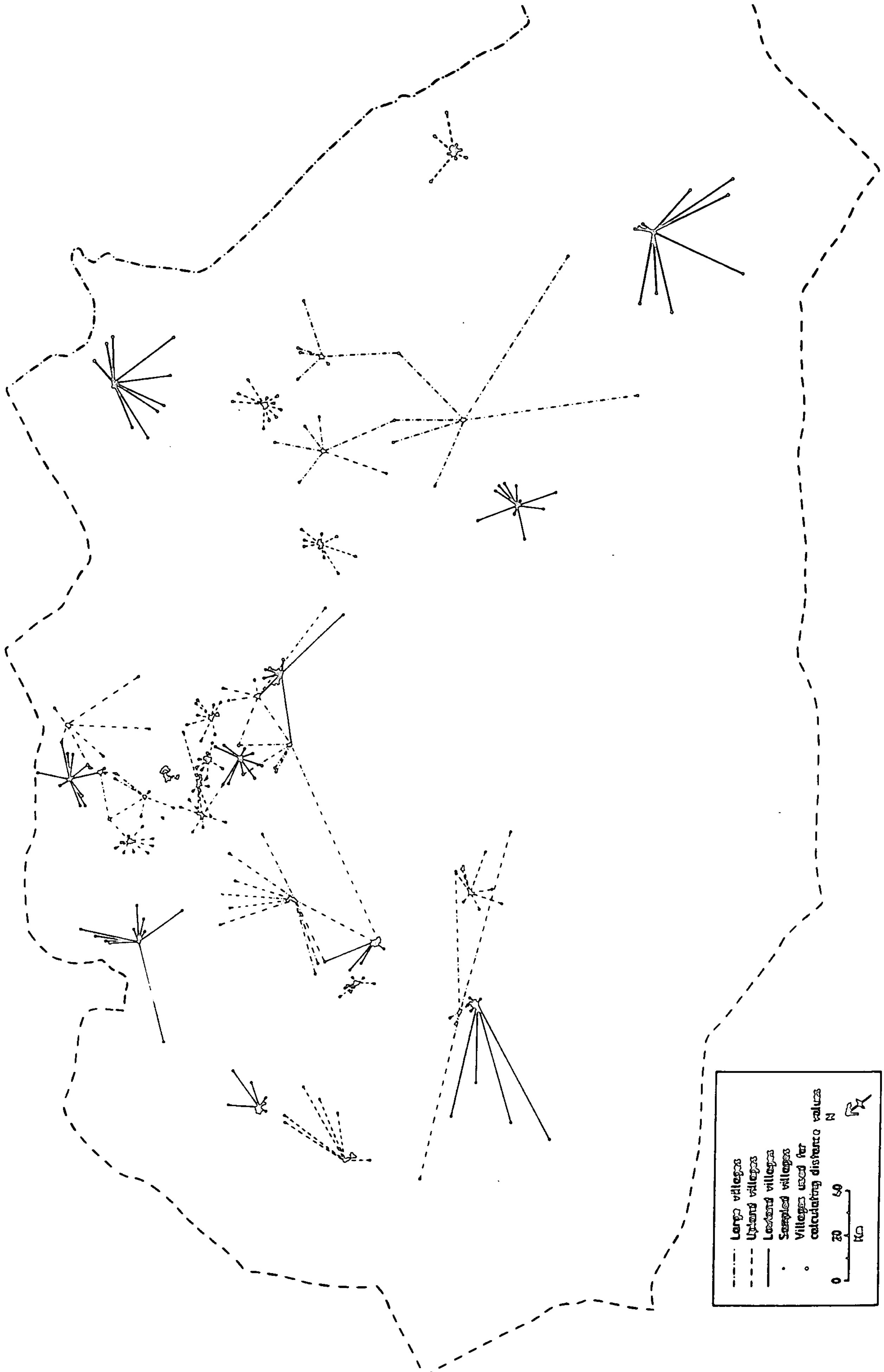


Figure 6.9 Sample average village spacing in south Khorasan. (note map orientation).

Table 6.5 Average spacing values

Region	Average spacing in lowland areas (km)	Average spacing in upland areas (km)	Average spacing in large villages (km)
Mashhad	4.9	7.2	12.7
Quchan	3.8	6.4	9.0
Shirvan	4.4	5.8	8.4
Bojnurd	10.9	7.3	10.3
Dargaz	5.5	7.5	11.2
Average North	5.9	6.8	10.3
Neyshabur	4.4	5.1	4.8
Sabzevar	9.5	7.2	10.6
Torbat-e-Jam	5.8	8.7	15.0
Torbat-e-Heydariyeh	9.0	5.6	9.2
Bakhezr	4.2	-	14.2
Esfarayen	4.9	8.2	12.4
Kashmar	7.7	7.0	10.0
Average Central	6.5	7.0	10.9
Birjand	17.5	6.1	23.5
Ferdows	17.5	6.0	21.1
Gonabad	15.0	5.2	14.0
Tabas	14.4	13.0	39.2
Average South	16.1	7.6	24.5
Average Province	9.5	7.1	15.2

(e.g. Jaqarq Zoshk, Golmakan and Vakil-Abad) are formed along the northern flanks of the Binalud mountains. Here, the climatic conditions and above all the availability of river water descending from the mountains have resulted in the expansion and growth of many fruit growing villages which are characterised by being large and comparatively closer together. Good examples of such upland villages are Zoshk, Abardeh, Shandiz, Kang, Dowlat Abad, Mayon, Hesar and Veyrani.

In the central division of Khorasan the range between the lowest and highest spacing value is higher than in the northern areas of Khorasan being 5.7 and 8.7 km respectively. The spacing is particularly close in the upland river valleys to the southern flanks of the Massif Binalud at Neyshabur (5.1 km), and Kuh-e-Surkh at Torbat-e-Heydariyeh (5.6 km), where due to the higher altitudes of these mountains the upland villages are better ordered and consequently more flourishing. Among the 14 minor sub-divided sampling areas (Bakhsh) the most densely settled upland villages are found in the Markazi district in Neyshabur shahrestan, having a spacing value of 3.4 km or more than two times lower than the average for the central division as a whole. In the Karrab district of Sabzevar, the average spacing among the upland villages of Central Khorasan is the highest (9.6 km).

In the south, however, a marked contrast in the spacing value of the upland villages is found between the eastern uplands dominated by the Kalat, Ferdows and Momen-Abad ranges and the relatively lower and less extensive range of Tabas to the west. In fact in the former upland areas the average spacing value is among the lowest in Khorasan being

5.2, 6 km, and 6.1 km in Gonabad, Ferdows and Birjand respectively. Though, as explained previously, the upland villages here, despite their low spacing, value are extremely small (with an average size of 101.2 persons) with much lower populations than in the centre or south. By contrast the upland villages of Tabas to the west have the highest upland spacing value (13 km). The differences in the value of upland spacing villages are particularly high among the minor sub-divided areas ranging between the lowest of 2.1 km in Shah-Abad district in Birjand shahrestan to as high as 16.8 km in the Dastgardan district in upland areas of Tabas shahrestan (see Table 6.5 and Figure 6.9).

Lowland areas : In Khorasan, since the location of lowland villages are closely related to groundwater availability (Chapter 5) it can be said that the location of the villages is greatly determined by the geographical location of groundwater supply (qanats, wells, and springs). However, since a great majority of these resources are distributed in the north and central areas, the villages in this part of Khorasan are not only considerably larger but also more closely spaced (being on average a distance of respectively 5.9 km and 6.5 km compared with 9.5 km measured for the region as a whole). In the south, by contrast, the sources of groundwater reservoirs are small and scattered, thus dictating both cultivated lands and villages to be small and widely spaced. The average distance between the lowland villages of this part of Khorasan measured 16.1 km, approximately three times greater than the average distance measured for the north.

Among the 16 shahrestans, Quchan and Shirvan in the north (3.8 km and 4.4 km respectively), and Bakhezr and Neyshabur in the central region (4.2 km and 4.4 km respectively) have the lowest spacing while the measured spacing for the southern shahrestans of Ferdows and Birjand is the highest (17.5 km). Among the 52 minor divisions (Bakhsh), the range in the spacing value of the lowland villages is particularly high being the lowest (1.3 km) in Darb Qazi district of Neyshabur and the highest (33 km) in the Khanchkuk district of Ferdows shahrestan.

Spacing among the large villages: By referring to the maps of settlement distribution (Figures 6.2, 6.4, and 6.6) and the spacing sampling data Figures 6.7, 6.8, 6.9 and Table 6.5), it is clear that there is a clear relation between size and spacing of the villages in the area. The larger the villages, the wider apart they are spaced.

For the region as a whole the average spacing between the large and medium size villages (villages with a population of more than 500 inhabitants) is measured at 15.2 km. In the north the spacing is generally lower (10.3 km). In the central areas it is slightly higher (10.9 km), while in the south due to the small and scattered distribution of agricultural lands, the large villages are comparatively much smaller in number and more widely spaced (24.5 km on average).

Among the 16 shahrestans of Khorasan the average spacing of larger settlements ranges between 4.8 km and 38.2 km. Spacing is the lowest in Neyshabur (4.8 km), Shirvan (8.4 km) and Quchan (9 km) and is the highest in southern shahrestans of Tabas (39.2 km) and Birjand (23.5 km).

CONCLUDING COMMENTS

This chapter has discussed various aspects of settlement sizes and densities, together with comments on the spacing between villages. Reference has been made to environmental constraints such as water supply and topography, but additional 'human' factors have also influenced settlement characteristics. This dimension is discussed further in the next few chapters.

CHAPTER 7 : LAND TENURE AND LAND REFORM

INTRODUCTION

The study of land tenure is important as the type of ownership affects the structure of rural settlements and the process of agricultural production. In this chapter the major types of land tenure are examined, using an historical framework.

LAND REFORM

Before the discussion of land reform and its effect, it is appropriate to give a brief background to the pre-land reform types of land ownerships, and the traditional structure of rural agriculture in the area.

Types of ownership before land reform: The general position of land ownership in Khorasan before the application of land reform is illustrated in Table 7.1. The table indicates that three major groups of holding dominated the pattern of ownership in each district; absentee owners (Arbabi), peasant proprietors and religious endowments.

The absentee holders most commonly seen among the large individual owners usually held more than one dāng of village (dang is one of the six parts into which village agricultural land is divided). According to the national census of 1956, this category of holding was found in about 37 per cent of the villages of Khorasan. The absentee holders usually lived in the town, and had the village headman (kadkhoda) or his agent (mobasher) in charge of the village. They neither employed farm workers nor received the total profit from any of his village land which might be farmed. His income came either from the tenant who rented his village or from the peasant farmers on the basis of a share crop agreement. The rates of rent payment in the form of sharecropping varied remarkably from one area and village to another. As pointed out by Issawi (1971, p.223) the share of landlords ranged from 10 per cent to as much as 80 per cent of crops, the share was regularly lower in rainfed areas than in irrigated land being on average 1:10 and 2:3 respectively.

It was also common for a village to have more than one owner, sometimes as many as two-hundred as for example in the following case:

"Golestone Torghabeh owned by approximately 200 families, only half of whom live in the village. The remaining one hundred owners live in Mashhad and each sends someone to the village to cultivate the land" (Taylor 1966 p.37).

The second major category of landownership in Khorasan was the endowed property (any private property which through legal action or a clause in a will has been made available for designated uses by the public or a segment thereof). According to the 1956 census, this category involved as much as 17.9 per cent of the villages in the area. The Emam-e-Reza Sharine and Gowhar Shad mosque in Mashhad owned about 400 complete villages and thousands of fractional parts of villages distributed all over the country, especially in the Khorasan area. The _owqaf_ institution usually rented out the _vaqf_ (religious) land to tenants; the following example from Flower (1966, p.6) is typical among the rented _vaqf_ properties. It is the case of the village of Kashaf near Mashhad which is endowed to the Shrine of Emam-e-Reza:

"Here, the landlord pays 70,000 tomans (£3.500) for the lease and he is allowed to do with the land virtually as he wishes. As well as this basic rent he also has to pay a yearly rent of 16 tons of wheat and 8 tons of barley to the Holy Shrine and this is usually sold by the Shrine for money for maintenance or is sold to the peasants when they are in need of extra supplies of wheat."

The final major form of pre-land reform ownership is peasant proprietorship which, as can be seen from Table 7.1, was very common among all districts in the area. This category encompasses all those who actually operate as well as manage part or all of the land as a farm. In this form of land ownership usually each family in the village had its own piece of land and worked individually.

In the pre-transaction period the ownership of the most fertile lands was concentrated in a few hands. The relationship between peasant and landowner was mainly on the basis of tenancy or share-cropping. In both cases the landowners would obtain most of the peasants produce as rent, interest or ownership. Thus, peasants had no incentive and felt no encouragement to exploit the land properly and more rationally. Consequently this resulted in poor productivity of agriculture in the area.

Traditional production units : Before land reform, the cultivated land in each village was divided into various small production units called *sahras*. A *sahra* was a piece of village land (usually less than 30 hectares) in which a number of peasants were grouped together and worked as a unit. The number and size of *sahras* and the number of peasants working in them usually varied from one village to another depending

Table 7.1 Types of Land Ownership (1956)

Area	Public domain villages	Endowed land villages	Farm-owned land villages	Arbabi-land villages	Institutional land (Non government)
Mashhad	16	343	466	692	8
Quchan-Shirvan	3	132	360	217	6
Dargaz	-	16	83	69	19
Bojnurd	81	103	311	233	-
Neyshabur	7	105	585	301	3
Torbat-e-Jam	6	20	258	212	1
Torbat-e-Heydariyeh	3	146	374	385	2
Sabzevar	1	222	403	300	-
Kashmar	-	80	125	108	-
Birjand	3	451	1122	923	4
Gonabad	-	93	158	97	-
Ferdows	1	46	65	27	-
Tabas	-	84	167	250	2
Total	121	1,841	4,477	3,814	45

Source : 1956 National Census, Khorasan Province.

largely on the village resources and in particular its source of water supply. For example Ahmad-abad-e-Doulate in Torbat-e-Jam area had a total of 14 sahras each consisting of 18 hectares of land, six men and six oxen; while in the village of Amqhan the number of sahras was 9 with 8 men working in each and in the case of Qaderabad and Nilabad, also in Torbat-e-Jam district, the corresponding numbers were respectively 9:8 in the former and 12:94 in the latter village (Lambton 1969 p.132, and Safinezad 1974 p.240). But within each village sahra shared the same characteristics. They were almost equal in size and had a similar share of village water supply. The general pattern and the allocation of each sahra to the different crops which was decided in the beginning of every agricultural year, was somehow that it could create an almost equal distribution of income among the village's sahras. For example each sahra received all sorts of plots, both good land and bad land and, as is shown by a typical sahra example in Ahmadabad-e-Doulat, (Table 7.2) each sahra's land was allocated to the production of both cereal and cash crops. Usually part of the land in each sahra was devoted to wheat and barley which was mainly for village consumption. Cotton, sugar beet and melon, which were the common cash crops in the area, also occupied part of the land. However, it should be noted that the allocation of the land under each crop was not the same in every village, it varied in accordance with the need for the production of wheat and barley as a source of food and the conditions of local and regional marketing for cash crops. For example the establishment of Abkuh and Fariman sugar beet refinery in Mashhad area affected the land use pattern and the traditional composition of crop production in the area to a large extent. Because of its relatively higher economic return in many villages landlords and landowners turned more and more land over to

Table 7.2 Cultivated area and production of different crops in one Sahra Unit in Ahmadabad-e-Doulat in Torbat-e-Jam area

Crops	Area under cultivation in hectares	Production in kg.	Gross value in Rials
Wheat	9	1,500	75,000
Barley	4.5	7,500	37,500
Cotton	3.6	2,400	40,000
Melon	0.18	Self consumed	-
Cumin Seed	1.2	7	35,000
Total	18.48	-	187,500

Source: J. Safinezad & Boneh 1974, p.24.

sugar beet to an extent that peasants had to buy their wheat from elsewhere (Flower 1966 p.32/50, also see Taylor 1966 p.44)

From the above discussion it is clear that under the traditional sahra system the land and the village resources were distributed equally among the sahra units and therefore members of sahras within each village had almost equal benefit. However, the fact that the village land was divided into various small sections which were usually less than 30 hectares created some problems in agricultural activities especially with irrigation and the use of agricultural machinery resulting in wastage of manpower and low productivity in the area. However, this problem of fragmentation was to a large extent inevitable due partly to the variation in the production sources such as quality of the land, and partly because of topographical conditions and the distance of land from the village and water supply.

The implications of land reform law (1962-1973): The Iranian land reform programme continued for a decade (1962-1973), during which the government purchased the land from landowners and then sold it to the peasants who already had the right of cultivation in village land (nasaq holders).

The land reform had three phases, in Khorasan the first phase was completed during the period 1962-1965. This stage of land reform mainly affected the large absentee owners who were then obliged to sell their holdings in excess of one village to the government. The second phase of land reform (1965-1969) was effected by various new articles. Accordingly the vaqf lands were rented to the peasants, and the landlords were to choose one of the following ways : selling direct to peasants, leasing for a 30 year period, redistributing their land by joint exploitation through a local organization, or dividing their land with the peasants in the ratio that formerly prevailed in the division of crops. The third phase of the land reform programme mainly concerned the small owners. Their lands were given to the peasants mostly on the basis of rent payments. The result of land reform presented in the following table indicates that by 1976 about 57 per cent of the total households of Khorasan received land while the remaining 43 per cent who did not have the traditional right of cultivation remained landless.

Table 7.3 Land reform Results in Khorasan Region

Number of peasants who purchased land in Phase One	42,694
Number of peasants who purchased land in Phase Two	312,663
Number of peasants who purchased land in Phase Three	52,561
Total number of peasants holding land (1966)	407,918
Total number of rural households in 1966	720,512
Total number of landless households (1966)	312,594

Source: 'Various'

It was only during the first stage of land reform that redistribution was mostly on equitable terms. During the second and third phases the added articles of July 1974 allowed landowners to be much more actively involved in the redistribution process and thus the more common pattern throughout the region was for a few peasants in any given village to acquire substantially larger acreages than the majority. In later sections we examine what effect this inequality had on the size of farm plots and the hectarage of the peasant household's holding.

Size of plots and land holding: As explained earlier, one of the main factors which in the pre-land reform period restricted agricultural activity in the villages was the fragmentation of village land into many small pieces. This problem, however, as will be explained below remained unsolved and was, in fact, aggravated by the application of land reform. The following example given by Lambton (1965, p.132) illustrates the process of disintegration of the sahra structure in Nilabad village, one of many examples in the area:

"In some villages in Khorasan the organization of the village land into sahras i.e. the arrangement by which a number of ploughlands were grouped together and worked as a unit, was changed after its transfer to the peasants. For example, in Nilabad near Torbat-e-Jam the village land was formerly divided into twelve sahras, each consisting of four ploughlands and worked by ninety-four peasants. After transfer, the sahras were subdivided into twenty-four, each consisting of two ploughlands."

On the basis of the results of the studies shown in Table 7.4 it is clear that the average extent of plots and the average amount of land owned by each household is generally very low, hardly larger than 1 or 2 hectares. The results also suggest that the size of plots and the average hectarage of peasant holdings is higher in the north and central parts of Khorasan but in the south the corresponding average are much lower, (as low as 0.26 and 2.55 hectares respectively). However, it is

Table 7.4 Land fragmentation in Khorasan by region

	Total Number of studied households	Households with fragmented land	Percentage with fragmented land	Average number of plots	Average amount of land owned by households in hectares	Average size of plots in hectares
Mashhad	324	75	75	6	14.47	2.6
Bojnurd	168	145	82	3.6	6.3	1.75
Dargaz	36	21	86	5	9.66	1.9
Neyshabur	198	183	94	11	11.79	1
Sabzevar	143	92	64	9	14.67	1.63
Kashmar	59	40	67	5	16.76	3.34
Birjand	168	163	99	6.7	3.33	0.49
Torbat-e-Jam	120	110	92	6.3	12.53	1.98
Gonabad	35	32	91	9.8	2.55	0.26

Source : Khosrou Khosravi (1972) p.168.

interesting to note that the minimum average area of land required to support one village family of five members at a basic subsistence level for one year is estimated to be seven hectares. That is, taking into account that annually about one-half of the cropland is left fallow, a family will require at least 3.5 hectares of land under crops to meet its basic subsistence needs or food and commodities each year. Thus it is clear that the productivity of the average 2 to 3 hectares of land per household estimated for the southern areas of Khorasan does not fulfil subsistence needs. As a result many peasants who received such a small piece of land had either to work as labourers in the fields of those who received more than seven hectares or to leave their land and village altogether. The seriousness of the problem is better understood by this explanation than if one accepts the quantity of seven hectares as an optimum size of holding for a peasant to maintain his family at the basic subsidence level. Accordingly if the total cultivated areas of southern Khorasan are divided into seven hectare plots then the number of holdings whose land may produce enough to maintain a family in their land and village will be 17,314. However, since the total number of households in the area is 83,584 (according to the 1976 national census) then it means that 66,270 of households, or about 79 per cent of the contemporary households will have to leave. The effect is particularly grave not only for rural communities and settlements in this part of Khorasan but also has serious implications for cities.

Inequality of Holdings Table 7.5 illustrates the dramatically inequitable pattern of peasant proprietorship following the completion of the land reform programme in Khorasan. The disproportionate distribution of land between different groups of holdings is clearly

Table 7.5 Land holding pattern in Khorasan

Size of Holding	Holdings		Land area	
	Number	%	Hectare	%
Less than 1 hectare	79,745	27.3	27,022	1.1
1 to 2 hectares	28,357	9.7	36,664	1.5
2 to 5 hectares	53,846	18.5	163,832	6.8
5 to 10 hectares	55,384	19.0	382,136	16
10 to 50 hectares	70,108	24.0	1,205,853	50.4
50 to 100 hectares	2,527	0.9	171,846	7.1
More than 100 hectares	1,776	0.6	408,244	17.1

Source : Statistical Centre of Iran, "Second Stage of the Agricultural Census results" 1977, p.20

evident in the Table. Only 1.5 per cent of the holders have more than 50 hectares, they own more than 24 per cent of the provincial total arable land, that is an equivalent to the land owned by 75 per cent of the holders.

CONCLUSIONS

To summarise the above discussion of land tenure and land reform it can be generally outlined here that the land reform did not solve the problem of land fragmentation which already existed in rural agriculture. The distribution of land was unjust and remarkably uneven and thus aggravated the problem of agricultural productivity, and low income among the poorer peasants. It has created more problems for agricultural activities such as irrigation, mechanization and land management and, above all, has had a drastic effect on rural migration and the abandonment of the villages. During the short period between 1966 and 1976 nearly one thousand of the villages were abandoned and Mashhad alone received more than 100,000 imigrants, many of whom came from rural areas and who left their land and villages, mainly because they did not obtain enough land to maintain their families at subsidence level. The following example by Lambton (1966) gives a general picture of the situation in which the fragmentation and uneven redistribution of the land affected the small landholders and aggravated the problem of migration.

"I happened to call at the land reform office in Torbat-e-Heydariyeh one morning when a small landowner from a village near the town came in. He worked his land with one peasant who, he alleged, wished to sell his rights. The head of the land reform office said this could not be done because the two parties had already agreed to set up an agricultural unit according to Article 17 of the regulations for the Additional Articles. The man went away and later brought back the peasant who was then interviewed alone. He said he wished to sell his rights and leave the district because his income from the land was only 40 mans (252 lb) of grain, on which he could not possibly live" (Lambton 1966, p.254).

Land reform had further impacts on settlement patterns by disrupting financial income. In particular, many peasants had insufficient money to invest in the repair of qanats and, together with widespread confusion about who owned, and was responsible for their maintenance, many sources of traditional water supply were lost. This point is taken further in a later chapter in the context of abandoned villages.

CHAPTER 8 : AGRICULTURAL LAND USE

INTRODUCTION

A study of land factors such as land use pattern, land use potential and land tenure is essential as they strongly influence the process of agricultural production and economy, and hence the pattern of rural settlements. The main aim in this chapter is to develop the theme of land reform to differentiate between the main types of land in the area according to their agricultural productivity and potential. This will also involve discussion of some of the wider issues of agricultural production, such as livestock potential and rural income. For this purpose the provincial land areas are first classified and examined in the two broad categories : of uncultivated (i.e. land unsuitable for development, potential rangeland and grassland, forest), and cultivated lands (i.e. land under cultivation of annual, perennial, and greenleaf crops.) Then the sub agricultural zones of Khorasan are classified and analysed in relation to cropping patterns and their generalised suitability for production of each major crop. In a later section the sub-divided agricultural zones are examined in terms of rangeland potentiality and whether they are a main livestock zone or mixed farming area, where livestock and cropping production are of importance. Finally, under the heading of land tenure there is some examination of the types and pattern of land ownership and size of land holding in Khorasan. The various maps, statistics and reports which are used in the study of landuse in this chapter are mainly provided by the Plan Organization Statistics Centre, and Ministry of Agriculture and Natural Resources.

UNCULTIVATED LAND

From the points of view of land use pattern and potential, the area of Khorasan can be divided into two main categories : uncultivated and cultivated land. This division results mainly from the impact of factors such as climate, soils and once again the conditions of water supply in the area. A detailed classification of these lands is shown by Figure 8.1 and Table 8.1.

Approximately 90 per cent of the total land areas of Khorasan is classified as unsuitable for cultivation in any one year. This can be further divided into four categories : land unsuitable for agricultural development, forest/fallow land and grassland and rangeland.

Land unsuitable for agricultural development : This is by far the largest category of land use in Khorasan, covering approximately 20 million hectares, or nearly two-thirds of the total land area. Of this total 12 to 15 million hectares are classed as absolutely wasteland and are excluded from any cropping or grazing use. They comprise either bare mountains, rocks and steep terrain, or sandy and highly saline areas. The remaining land, classed as unsuitable for agricultural development is formed by very poor desert soils such as regosols, calcarious lithosols, and salt plugs. These soils generally suffer features of salinity, aridity and erosion and in their present form can only provide poor potential land use for grazing. Any future potential of these soils will be dependent on reclamation work which normally requires intensive leaching and expensive artificial drainage. It is only in the limited plains of Khorasan, Sarakhs, Esfarayen and Torbat-e-Jam that future allocation might be possible by the additional potential of water estimated between 20 to 100 mm^3 per annum. Over

Table 8.1 Land utilization in Khorasan

Land area	Total land area in hectare	%
Cropland	3,000,000	9.6
Potentially cultivable	1,000,000	3.2
Rangeland	6,000,000	19.1
Forest and potential grassland	1,000,000	3.2
Urban and rural settlement	350,000	1.1
Unsuitable for development (Desert and other waste land)	20,000,000	63.8
Total	31,300,000	100.0

Source : Plan Organization, present agricultural and livestock situation in Khorasan Region, proposals for the fifth plan, 1972.

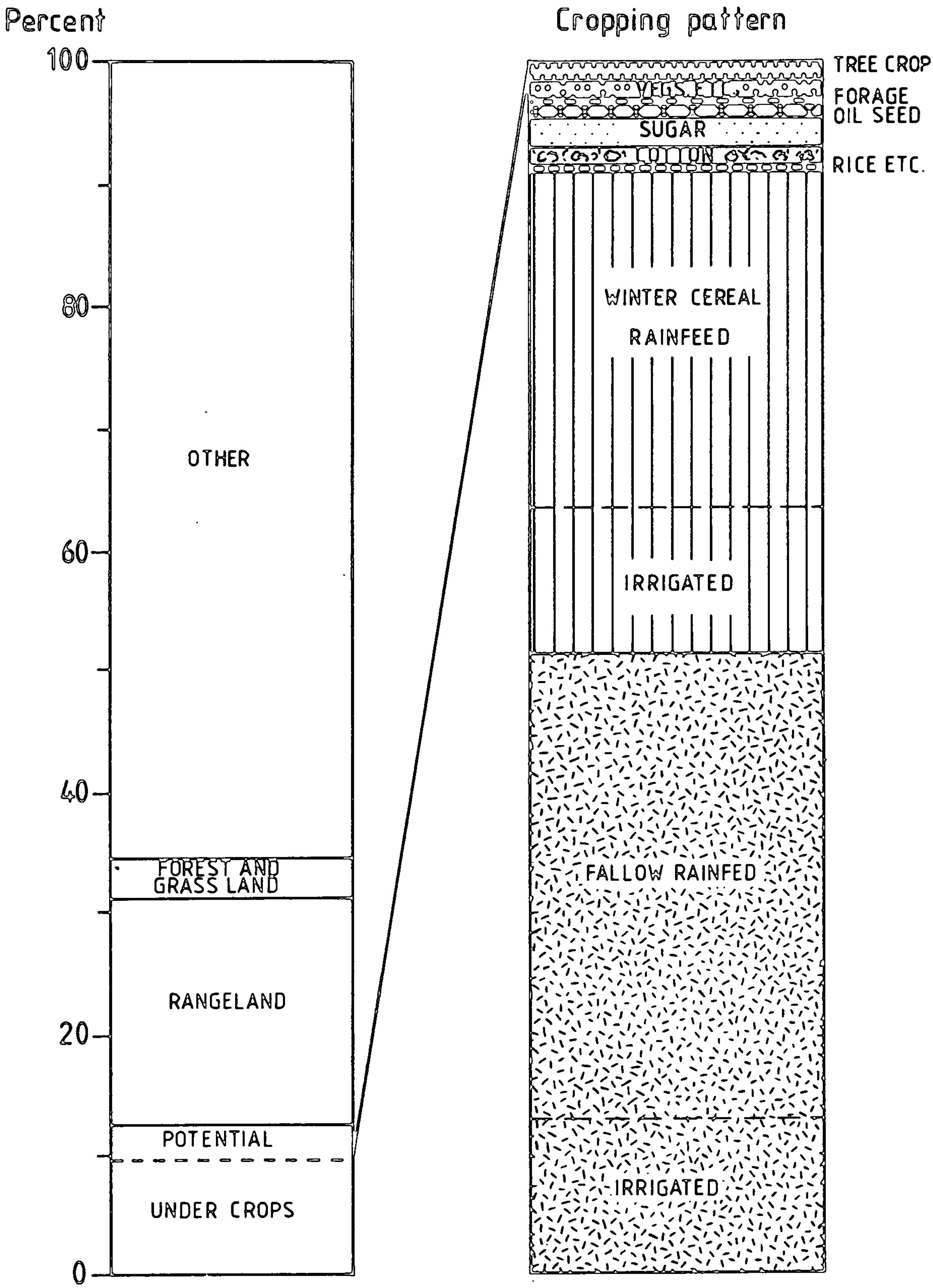


Figure 8.1 Land use and cropping patterns for Khorasan.
(based on National Cropping Plan, 1975).

much of the region where these soils are predominantly found (i.e. lower parts of the central basins and desert areas of the south), the reclamation and leaching is not possible for, as has been explained in Chapters 4 and 5, there is virtually no water available, and what there is tends to be very saline.

Forests : According to the agricultural census of Iran, a forestry area is defined as an area comprising at least 250 trees per hectare. The forestry resources of Khorasan are sparse and limited. The highest estimate given for the forest and woodland areas of Khorasan is 300,000 hectares, or only about one per cent of its total area. The largest and densest forest localities are found along the Binalud mountain range and particularly in the Bojnurd area. A good example of such localities are Ghazanghayeh (pistacio forest), Dareh-Bid (oak forest), and Emam-Dareh (juniper forest). In the past the forestry resources of Bojnurd have been much more extensive. This is evident from the Plan Organization Report (1975) which gave an estimated figure of 70,000 ha. for the destroyed forest remaining in the area. Although these areas are now under the protection of the nationalisation law, they are still being exploited by the local villages for various resources (i.e. firewood, charcoal, and roofing).

Despite their present low coverage the forestry resources of Khorasan are a valuable asset in the area. Apart from economic advantages, they have a favourable influence on climate and also serve as a source of pasture land.

Fallow lands: B.H. Janssen (1972) used his experimental evidence in the great Konya Basin, Turkey to suggest that 450mm rainfall per annum is the lowest limit for full effective fertilizer use by any crop and that below the limit of 450 mm fallow years in the rotation are desirable (fallow land comprises the land not cultivated or irrigated in any one year or season). Janssen's tentative scheme of the coherence between annual precipitation and desired rotation is as follows:

Precipitation (mm)	Desired rotation	Nitrogen dressing
Less than 200	no wheat cultivation possible	-
200-260	2 years fallow 1 year wheat	no
260-350	1 year fallow 1 year wheat	depends on soil content
350-456 year	1 fallow 1 year wheat	small dressing desirable
more than 450	permanent cultivation	N dressing replaces fallow year

As has been explained in Chapter 3 the amount of annual rainfall in Khorasan region is, almost everywhere, below 450 mm, and therefore by taking Janssen's view into consideration, the application of fallow years in all dry-farming areas of Khorasan becomes necessary if good yields are to be expected. Accordingly, the rotation of crop-fallow-crop in alternative years is essential in the low potential rainfed areas of Bojnurd (300-450 mm annually); whereas in the sub-marginal areas of Mashhad, Neyshabur, Torbat-e- Heydariyeh (300-200 mm annually), dry-farmed land may lie fallow for a period of more than two years. However, in the irrigated areas the extent of the fallow period is much smaller. The usual pattern in these areas is to rotate a given field between fallow and irrigated land in such a way that it lies fallow every third year.

Table 8.2 shows the extent of irrigated and rainfed areas which have lain fallow each year during the period 1971-1978. It is clear from this table that the proportion of fallow lands to the cultivated areas was 41.6 per cent in irrigated areas, 54.9 per cent in dry-farming areas, and for the total irrigated and rainfed lands it was 51.0 per cent. The high proportion of fallow lands in Khorasan is clearer when it is compared with that estimated for the same year for the country as a whole, that being 34.0 per cent, 43.1 per cent and 39.9 per cent respectively.

Grassland and rangeland : Potential grassland forms approximately 2.2 per cent of the total land area of Khorasan. This type of grazing land is suitable for intensive grazing and carries a capacity of 10 to 15 hectares per composite sheep unit. A highly potential area of grassland is confined to the southwest of Bojnurd which is the rainiest part of Khorasan (annually between 400 to 500 mm.) The potential rangeland is the second largest category of land use in Khorasan, occupying approximately 6 million hectares or 19.1 per cent of the total land area. This is now discussed more fully in a separate section.

RANGELAND AND LIVESTOCK

Those areas neither occupied nor under cultivation by man are considered rangeland. Although in Iran this category of land is nationalized, private individuals may use it as a source of livestock nutrition. There are, however, certain restricted areas set aside for purposes such as afforestation, erosion control and catchment management.

Table 8.2 Proportion of fallow lands to the total rainfed and cultivated areas (1971-1978)

Year	Irrigated			Rainfed			Total		
	Cultiv-ated area	Fallow land	%	Cultiv-ated area	Fallow land	%	Cultiv-ated area	Fallow land	%
1971	873	375	43	2667	1612	60	3540	1987	56
1972	777	291	37.5	1302	464	35.6	2079	755	36.3
1973	960	432	45	1718	622	36	2678	1054	39
1974	805	340	42	1590	526	33	2395	866	36.2
1975	1009	466	46	1494	526	35	2503	992	39.6
1976	-	--	-	-	-	-	-	-	-
1977	914	379	41	1458	567	39	2372	946	39.9
1978	804	348	43	1389	442	32	2193	790	36

Source: Various sources

<u>Distribution</u>: Khorasan's rangelands, while covering an extensive area of some 12 to 15 million hectares, provides only a limited source of livestock nutrition. According to the Farm Machinery Corporation Report (1975) rangelands are estimated to provide adequate nutrition for only 20 per cent of the grazing population in the area. The remaining 80 per cent of nutrition needs are provided by other sources (i.e. fallow and stubble, permanent crops, forage crops, cereal grazing and crop production), thus indicating that the rangeland grazing resources of Khorasan are predominantly poor and can only be used extensively.

In view of the rangeland potential map (Figure 8.2), rangelands of Khorasan may be divided into four following major categories : herbaceous, shrub and scrub, poor and very poor quality.

i) Herbaceous type : This category of grazing rangeland has greatest potential in the area, carrying an acreage capacity of 10 to 15 hectares per CSU (composite sheep unit). From the point of view of potential it can be divided into two classes. These classes are (a) semi-extensive grazing land which is formed in low potential rainfed areas, predominantly along the central and southern mountain ranges and (b) more close herding and better quality grazing land which is found along the northern high mountain range to the north west and southwest of Mashhad, and in particular, in the Bojnurd area (see Figure 8.2).

ii) Shrub and scrub type of rangeland : This is generally an extensive zone of grazing with a capacity of between 25 to 35 hectares per CSU. It is distributed on the periphery of the herbaceous zone or sub-marginal rainfed areas (rainfall between 200 to 260 mm.). Better

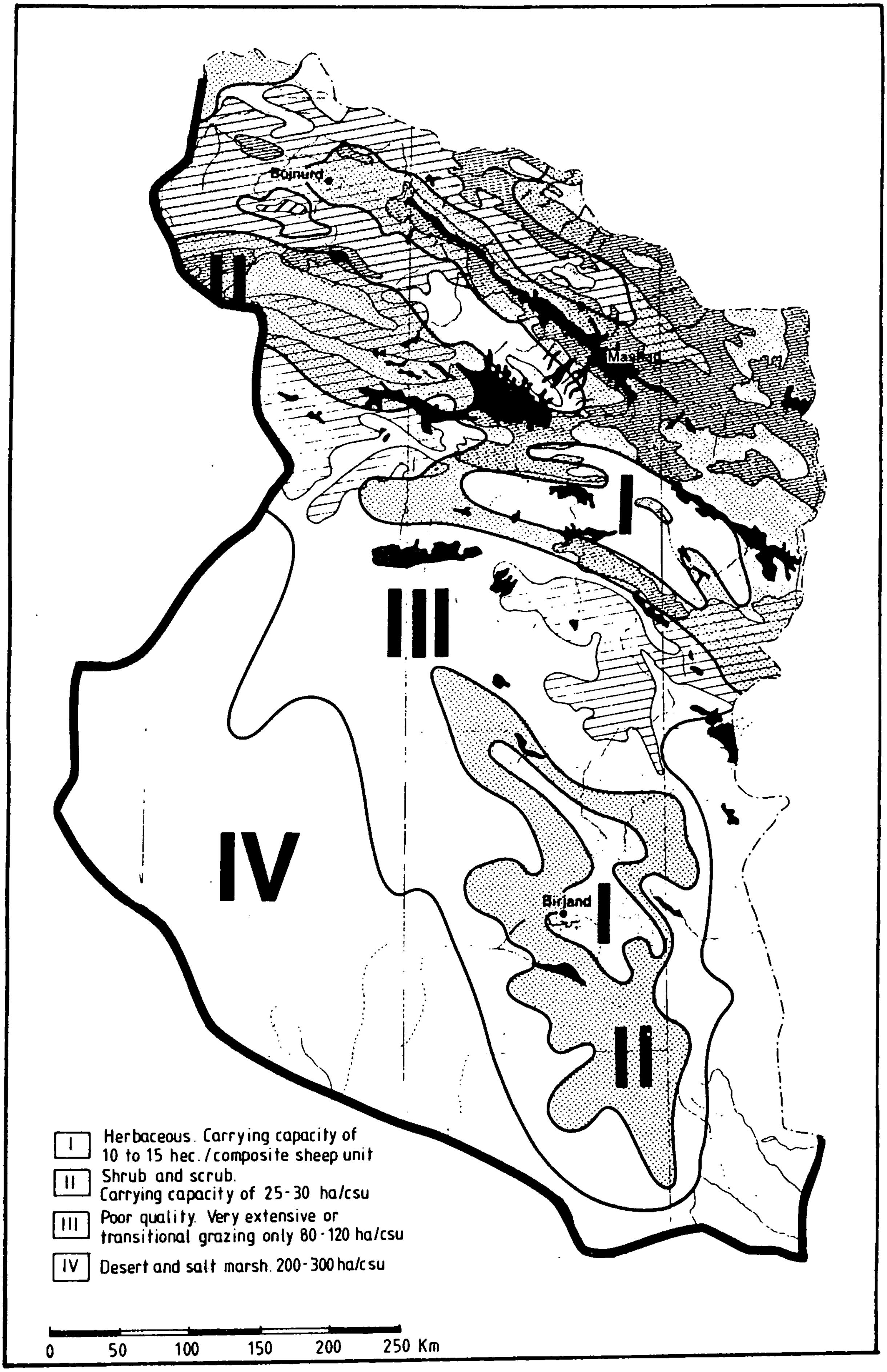


Figure 8.2 Rangelands of Khorasan extracted from the National Cropping Plan, 1975.

quality grazing rangeland of this type is found in the Mashhad, Quchan, Shirvan, Sarakhs, and Neyshabur areas (Figure 8.2), where rainfall figures are slightly higher, coinciding with better quality soil.

iii) Poor quality rangeland type : This is a very extensive or transitional class of rangeland grazing carrying a capacity of 80 to 120 hectares per CSU. This category is developed in marginal desert areas of Khorasan (rainfall 100 to 200 mm annually). As can be seen from Figure 8.2, it is the largest category in the area situated between the sub-marginal rainfed areas (shrub and scrub zone) and desert lands. The quality of this potential type of grazing rangeland is generally very poor and it is only in limited areas where soils have moderate potential (i.e. Sabzevar and southeast of Torbat-e-Heydariyeh, Figure 8.2) that semi-extensive grazing is found.

iv) Very poor to nil potential types : This category is found in sandy desert and salt marsh areas (rainfall less than 100 mm per annum). It is classed as the poorest quality of rangelands with an approximate capacity of 200 to 300 hectares per CSU. Due to its very poor quality and the decline of nomadism, the rangelands of this type are, in most parts, abandoned as far as livestock grazing is concerned.

<u>Livestock and integrated livestock zones</u> : With reference to the map showing livestock and integrated livestock areas (Figure 8.3), the sub-agricultural zones of Khorasan may fall into two major categories; either livestock production is the major occupation, or the emphasis is on mixed farming where livestock production and cropping are of equal importance. However, it should be noted that this overall

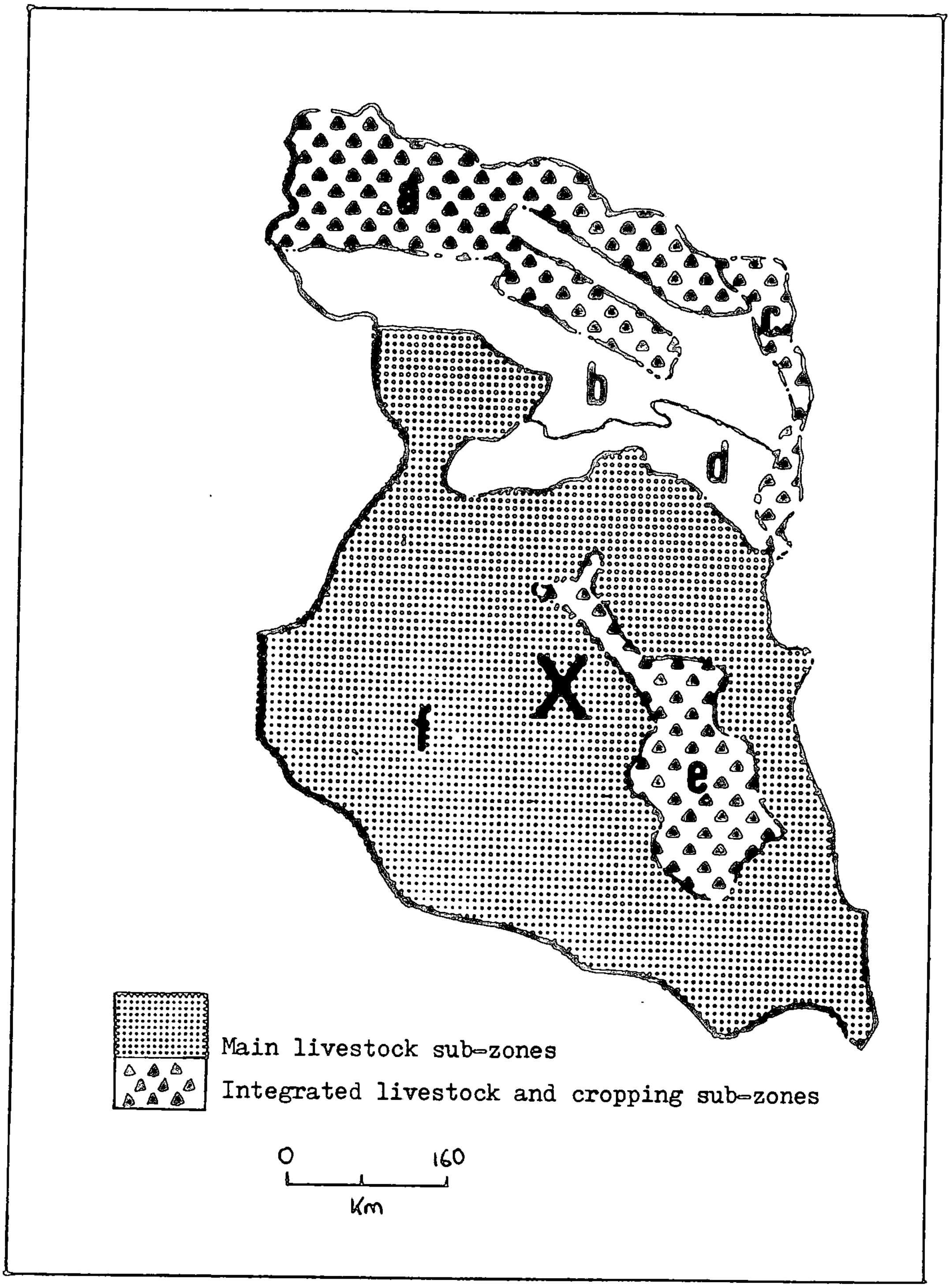


Figure 8.3 Potential livestock areas of Khorasan extracted from the National Cropping Plan, 1975.

classification does not deny the presence of livestock in cropping zones, or crop production in livestock zones but indicates the importance of the major agricultural activity in the area.

Main Livestock sub-zones : As can be seen from Figure 8.3, zone f is the only part of Khorasan where agricultural activity is predominantly based on livestock production. This zone occupies over half of the total land area of Khorasan, but owing to the poor quality of grazing land, overgrazing, and the loss of its better grazing areas to cropping, it can only provide a small proportion of nutrition needs, and a large proportion of the livestock population is moved outside this zone usually to the northern areas.

Mixed farming and cropping sub-zones: The zones which are considered under the heading of mixed farming are zone a (Bojnurd and Dargaz), zone c (Sarakhs) and zone e (Birjand and Qaen highlands), These zones are generally mountainous and comprise the rainiest parts of Khorasan. Therefore both dry-farming and livestock production are of equal importance.

In the remaining areas (zones b and d) cropping is the major agricultural activity although some livestock is dependent on it. These zones are sub-marginal, but owing to the noticeable availability of groundwater resources they are considered as mainly irrigated cropping zones. These zones are also regarded as convenient for wintering transhumant stock.

CULTIVATED LAND

Although agriculture has the most influential role in the life and economy of the region, its used and usable land resources are severely limited. Out of a total of 31 million hectares of provincial land it is estimated that only 4 million hectares (13 per cent) are potentially productive (of which only about 2.5 to 3 million hectares are cultivated at any one time). Thus, it is clear that the existence of over 8 thousand settled villages and more than 2 million people living in them is directly dependent on these limited available land resources, or more precisely on 1.5 million hectares of cropped land (a further 1.5 million hectares is reduced to fallow land). Moreover, as Table 8.3 indicates, there is a considerable regional variation in land utilization. The ratio of cultivated land to total area ranges from below one per cent in the south to 9.3 per cent in the central area and to about 11.7 per cent in the north.

In the following sections the cultivated areas of Khorasan will be examined in two main categories governed by two distinct sources of water supply, dry and irrigated lands. Under each the potentiality and distribution of agricultural lands is examined.

Dry-farmed areas; patterns and potentiality : Despite the fact that Khorasan is not climatically ideal for dry-farming, this method is widely practised in the area. Statistics (Table 8.4) indicate that each year, approximately 1.5 million hectares or about two-thirds of the total cultivated land area is under dry-farming. One clear feature is that, due to marked variation in the amount of annual precipitation, the extent of dry-farming may change greatly from year to year. For example, during two successive years, the extent of rainfed farming

Table 8.3 Extent of cultivated lands by regions

	Total area	Total cultivated-land	%
North	5,852,100	687,000	11.7
Centre	8,492,300	783,700	9.3
South	16,989,300	121,200	0.7
Total	31,333,700	1,591,900	5.1

Table 8.4 Extent of dry-farming areas (1971-1978)

Agricultural year	Total cultivated area	Dry farming area	%
1971	3,540	2,667	75.3
1972	2,079	1,302	62.6
1973	2,678	1,718	64.2
1974	2,395	1,590	66.4
1975	2,503	1,494	59.7
1976	-	-	-
1977	2,372	1,458	61.5
1978	2,193	1,389	63.3

Source : Various sources

areas varied by more than 100 per cent, from 2,667 hectares in 1971 to 1,302 hectares in 1972. Another main feature which is also reflected by the nature of precipitation in the area is marked regional variation in the proportion of dry-land utilization. As indicated by the following Table, (Table 8.5) in 1970 for example, the percentage of dry-farming varied from 8.0 in the north to 5.9 in the centre and to as low as 0.4 in the south.

Table 8.5 Proportions of the dry-farming land to the total area, by regions

	Total area (in hectare)	Area under dry farming (in hectare)	% age
North	5,852,100	468,000	8.0
Centre	8,492,300	498,000	5.9
South	16,989,300	75,000	0.4

Source : Plan and Budget Organization of Khorasan, 1975.

Based on the precipitation pattern as affecting both the need for fallow years in the rotation and the productivity of the land, the dry-farmed areas of Khorasan may fall into three landuse capabilities : high potential, low potential, and sub-marginal. Rainfed farming is found to be highly favoured when practised in areas receiving more than 400 mm rainfall per annum. In this potential category there is good scope for improving yields, and an average yield between 1.2 to 2.0

tonnes per hectare can be expected with correct input (Ministry of Agriculture Report, 1975). In Khorasan the high potential rainfed area is limited and constitutes only about 20 per cent of the region's total rainfed areas, which is in fact 10 per cent less than the proportion set by NCP data for the country as a whole. These lands are almost entirely confined to the northwestern parts of Khorasan and, in particular, in the areas to the south-west of Bojnurd town, where rainfall figures are the highest in the region - ranging between 400 and 500 mm per annum.

In the low potential rainfed areas the distribution of rain is critical (annually between 250 to 350 mm) and thus the rotational fallow system is considered necessary. In this category yields are very low (in Khorasan about 0.2 to 0.3 tonnes per hectare) and there is little room for improvement, though NEP reports (1975) claim that if correct input is given to such land yields will increase by a further 0.6 to 1.0 tonnes per hectare. Low potential rainfed areas are mostly found in the Bojnurd and Birjand highland areas, wherever the conditions of soil and slopes allow the use of land for cultivation. Here, rainfed cultivated lands are sometimes found in altitudes of up to 1700 metres (Saiedi 1974).

Dry-farming is classed as sub-marginal (NCP, 1975) when practised in areas receiving less than 250 mm of rain per annum, the figure considered as the lower limit for all rainfed farming. Despite its uncertain economic output, the sub-marginal area comprises over 60 per cent of the total rainfed cultivated land of Khorasan. Mashhad, Quchan, Neyshabur, Sabzavar and Torbat-e-Heydariyeh (rainfall ranging between 200 and 260 mm), have the largest concentration of this category of potential rainfed land. Although in these areas farming is mainly dependent on irrigation, dry-farming is also widely practised for two reasons. Firstly, because of the problem of water shortage, the improvement and the expansion of the irrigated lands is limited and, as will be explained in a later section, it is by no means sufficient to cope with the rapid growth of population. As a result peasants have found themselves obliged to expand the dry-farming areas in order to supplement production of the wheat and barley which comprises the major part of their diet.

In view of the above discussion, it can be concluded that the spatial expansion of agricultural production in the dry-farming areas of Khorasan make for extensive rather than intensive cultivation and the expansion of the area does not imply a parallel increase in productivity. Due to low levels of productivity, these lands cannot support a large number of population, and have little agglomerative effect on rural settlements. The villages depending on dry-farming are usually small (mostly below the provincial average size of 250), scattered and are therefore more at risk of being abandoned. Their future existence is particularly uncertain in sub-marginal rainfed areas partly due to government policy to stop or reduce dry-farming in these areas and partly due to the fact that productivity of these lands is extremely low, a problem which is exacerbated by erosion and soil exhaustion.

Irrigated land area : pattern and potentiality : Of the total 800 thousand to 1 million hectares of land classed as irrigated each year, by far the largest proportion is devoted to annual crops and fallow lands respectively about 51 per cent and 42 per cent of the total). The percentage of perennial and greenleaf crops is thus comparatively very small. As in the case of dry-farming areas the ratio of irrigated lands to the total area is very low and this trend increases towards the south (Table 8.6). A particularly low ratio in the south is not unexpected as most of the areas in this part of Khorasan are wastelands, and with its extensive land area (about 55 per cent of the province), shares only a limited amount of the available source of water supply (about 10 per cent of the province's total).

Table 8.6 Proportions of the irrigated cropped land to the total area, by regions

Area	Total area (in hectare)	Area under irrigated crops (in hectare)	Ratios
North	5,852,100	219,000	3.7
Centre	8,492,300	285,700	3.4
South	16,989,300	46,200	0.3

Source : Plan and Budget Organization of Khorasan Province, 1975.

The irrigated lands in Khorasan can be divided into two main categories : project and non-project lands. Owing to the problems of water shortage and unfavourable characteristics of the river sources, the proportion of land under government irrigation projects is small. By the end of the Fourth Development Plan (1973), there were only 25,000 hectares of such lands in Khorasan which according to the Yekom consultants' estimation (1974) is predicted to increase to 78,600 hectares by the end of the eighth development plan (1993). The total amount of water required for the irrigation of about 53 thousand hectares of new-project land and 19 thousand hectares of non-project improved lands, is also estimated by Yekom to be around 887 million m^3, of which 517 million m^3 or 58.3 per cent will be provided by surface water irrigation projects, and the remaining 370 million m^3 or 41.7 per cent are to be wholly provided by groundwater. Almost the entire surface water needs planned in the irrigation projects are to be fulfilled by the northern rivers of Khorasan (i.e. Tajan, Tabarik, Qoljoq, and Durungar), and therefore it can be assumed that a larger proportion of the new lands under government projects will be distributed in the north. In central and southern Khorasan, since the surface water is remarkably poor and erratic, the irrigation projects are small and mainly dependent on the availability of groundwater, wherever an additional potential is expected to be available (see Chapter 5).

Non-project lands (lands irrigated by private farmers), constituted 464 thousand hectares or about 94.9 per cent of the total irrigated areas in 1973. Of the total non-project lands 88.4 per cent were unimproved (lands receiving less than an adequate supply of 6200 million m^3 per hectare) and the remaining 11.6 per cent were classed as improved (lands which in the past had been unimproved and had then been provided with an adequate supply of water for full development). In Khorasan these lands receive between 7 to 10 thousands m^3 of water per hectare. According to Yekom's estimation (Table 8.7). the improved category will increase to 73 thousand hectares by 1993. The additional water required for these lands is to be provided by improvements to surface storage reservoirs and improved water distribution systems such as surface and underground canals.

Table 8.7 Development of irrigated land in Khorasan at the end of each 5 year period

Years	Total irrigated land	Land irrigated on projects			Land irrigated off projects			New irrigated land on projects
		Unimproved	Improved	Total	Unimproved	Improved	Total	
1973	489	0	25	25	441	54	464	0
1978	495	0	25	25	408	56	464	6
1983	516	0	25	25	402	62	464	27
1988	537	0	25	25	395	69	464	48
1993	542	0	25	25	391	73	464	53

On the whole, regarding the region's extensive size of area and its large number of population, the land resource of Khorasan is indeed limited and there is not much scope for its expansion. During the period between 1966 and 1976, while the land under irrigation decreased by nearly 10 per cent (from about 550 thousand hectares to 500 thousand hectares), the population of Khorasan increased by nearly 30 per cent from 2,518,526 in 1966 to 3,264,398 in 1976. As was explained earlier, irrigation projects planned for the future are small and designed mainly to increase the productivity of unimproved lands. In view of the Yekom prediction, only 53 thousand hectares of new land are expected to be brought under irrigation by 1993, that is an increase of nearly 11 per cent between 1976 and 1993, while for the same period a 55 per cent increase in population is expected. This means that villagers are obliged either to bring more rangelands into dry farming (if the conditions allow) or to leave their settlements. In either case the result is the long term abandonment of many of the villages in the area.

LAND USE FOR SPECIFIC CROPS

In this section of the chapter it is intended to show the pattern of land use for the major crops produced in the area, and also to evaluate the suitability of different agricultural zones for production of specific crops. The crops which will be examined here are wheat, barley, cotton, sugar-beet, sunflower, fruit and vegetables. These are considered the most important crops produced in Khorasan region. The following study concerns the major sub-divisions of the northern, central and southern regions which are further divided into six minor agricultural zones (Figure 8.4). This latter division takes account of local characteristics of soil, topography and climate in relation to crop ecology (Ministry of Agriculture, 1975).

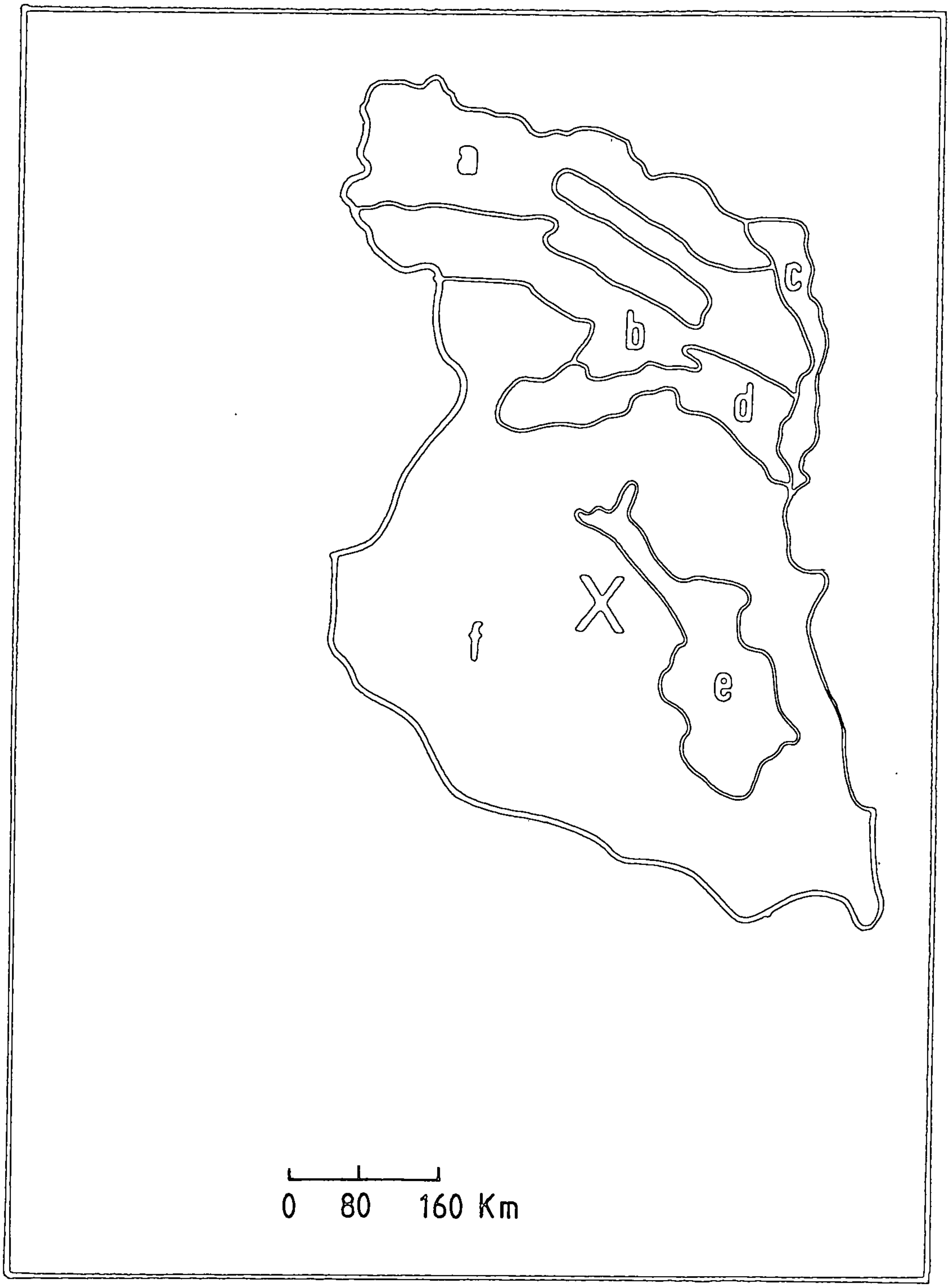


Figure 8.4 The six minor agricultural zones derived by the National Cropping Plan, 1975.

Land use pattern and zonal suitability for cereal production : Because of its harsh and cold winter conditions, as well as limitations of water and soil, Khorasan has few alternatives for crop production. Wheat and barley are the only crops to be widely cultivated under these conditions and they are considered to be well suited, as barley especially requires little water and both have greater salinity tolerance and show more flexibility in temperature conditions. Another reason for the dominating role of wheat and barley in the cropping pattern (together they account for nearly 80 per cent of the total cropped area and are cultivated in almost every settlement) is that they form the major part of the peasants' annual diet. Thus their importance cannot be ignored.

The areas found to be most suitable for the cultivation of rainfed and irrigated wheat and barley are outlined on Figure 8.5. Only zone 'f' is excluded (which is unsuitable for almost every sort of major cultivation). The remaining agricultural zones are considered to be well suited for the production of winter wheat and barley providing they are irrigated. In the case of rainfed farming the well suited but low potential areas are limited to zone 'a' alone which tends to have between 300 to 500 mm of rainfall annually, the highest in Khorasan. Outside zone 'a' the distribution of rainfall is critical and rainfed cultivation of wheat and barley are only of local importance, mostly in scattered upland areas around Kuh-e-Sorkh and the Qaen-Birjand highlands.

Land use patterns and zonal suitability for cotton: Unlike wheat and barley, cotton cannot be grown successfully in high altitudes (above 1300 m) or in conditions of prolonged cool weather. Cool weather conditions increase the length of the growing season, and also reduce

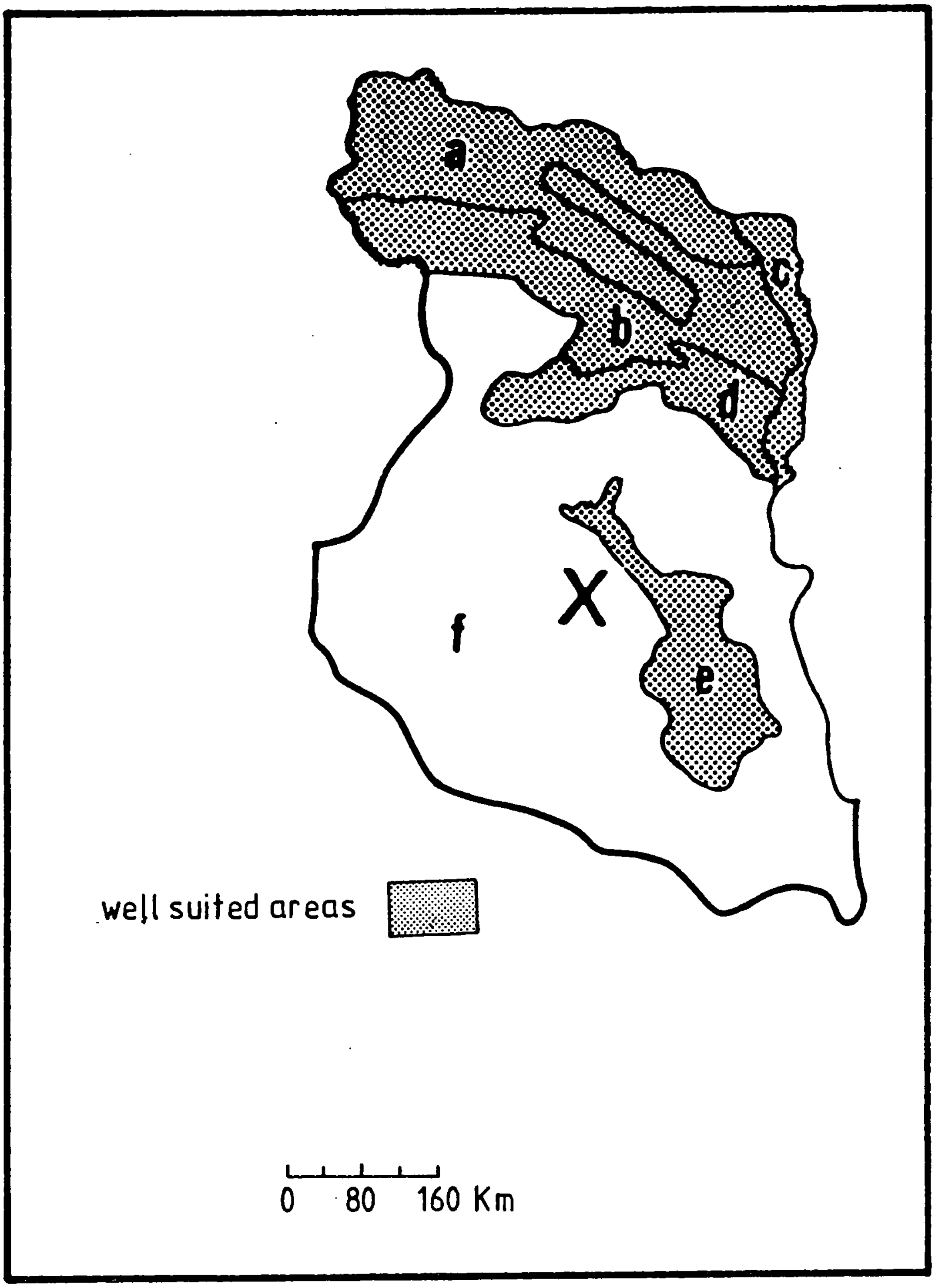


Figure 8.5 Potential areas for irrigated wheat and barley extracted from the National Cropping Plan, 1975.

the quality of the crop. As a result the suitability of the area for cotton production increases southwards from a cooler area in the north (zones a,c and northern parts of zone b) to a comparatively warmer climate of the central (zone d and southern parts of zone b), and further to the southern areas of Khorasan (zone e). This latter zone, although climatically well suited, owing to its problem of water shortage for irrigation constitutes only a small proportion of the land under cotton production (about 12.6 per cent of the provincial total). The largest concentration of land under cotton (60.2 per cent of the provincial total is found in the central division which is generally considered to be locally well suited, and the remaining 27.2 per cent is distributed in the north. The distribution of the land under cotton has been outlined in Table 8.8 as well as in Figure 8.6

Table 8.8 Land under cotton cultivation by regions

Region	Area cultivated (in hectare)	%
North	12,500	27.2
Central	27,700	60.2
South	5,800	12.6
Total	46,000	100.0

Source : Ministry of Agriculture and Natural Resources.

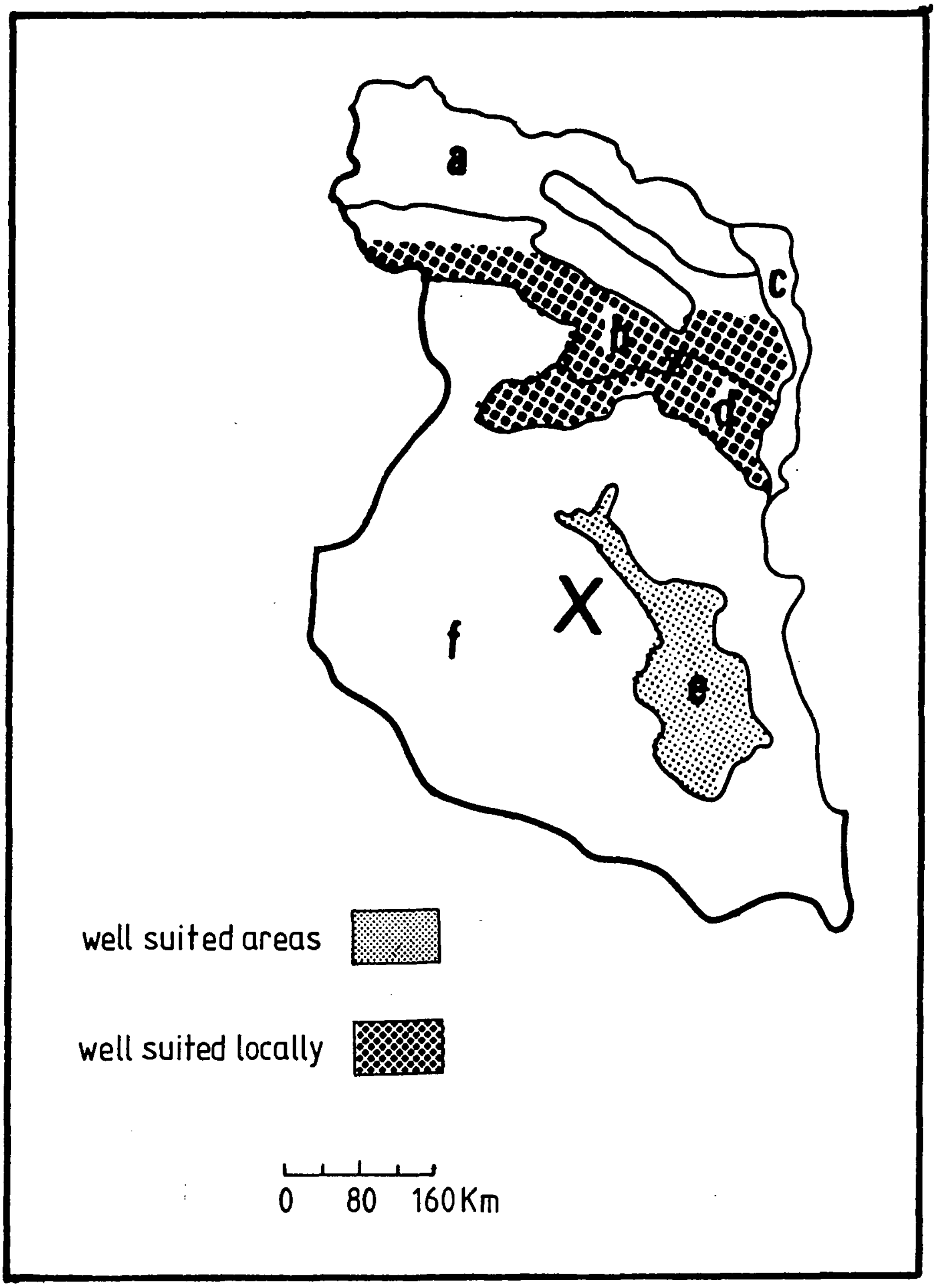


Figure 8.6 Potential areas for cotton production in Khorasan extracted from the National Cropping Plan, 1975.

It should be pointed out that until about 1960 cotton was the most important cash crop in Khorasan, and since then its importance has been generally declining, being replaced by sugar beet production which is climatically more suited to the area. This is particularly true in the case of the northern area of Khorasan which, while its cool climate is favourable for sugar beet, is considered unsuitable for cotton.

Land use patterns and zonal suitability for sugar beet : Khorasan is the largest sugar beet producing region of Iran. Each year some 60 to 70 thousand hectares (about 50 per cent of the total area of beet cultivation in the country as a whole) is devoted to the production of this cash crop. Its increasing expansion over the years from 22 thousand hectares in 1960 to around 70 thousand in 1975 has largely been due to increasing demands through the establishment of local sugar refinery factories, higher economic returns in comparison to traditional cereals and the fact that in comparison to other major cash crops such as cotton, it is less vulnerable to unpredictable weather conditions and thus economic returns are more assured.

The main cultivated areas and the zonal suitability for sugar beet production are shown by Figure 8.7, which shows that with the exception of zone 'f' most agricultural zones are considered well-suited areas. The largest concentration of land under sugar beet is found along the Atrak-Kashaf Valley, constituting about 59.0 per cent of the provincial land under this crop. Torbat-e-Jam, Sabzevar, Neyshabur, and Torbat-e-Heydariyeh in central Khorasan are also important producing regions with approximately 37.8 per cent of the land under sugar-beet. South of Khorasan, again due to the obstacle of water shortage, the area

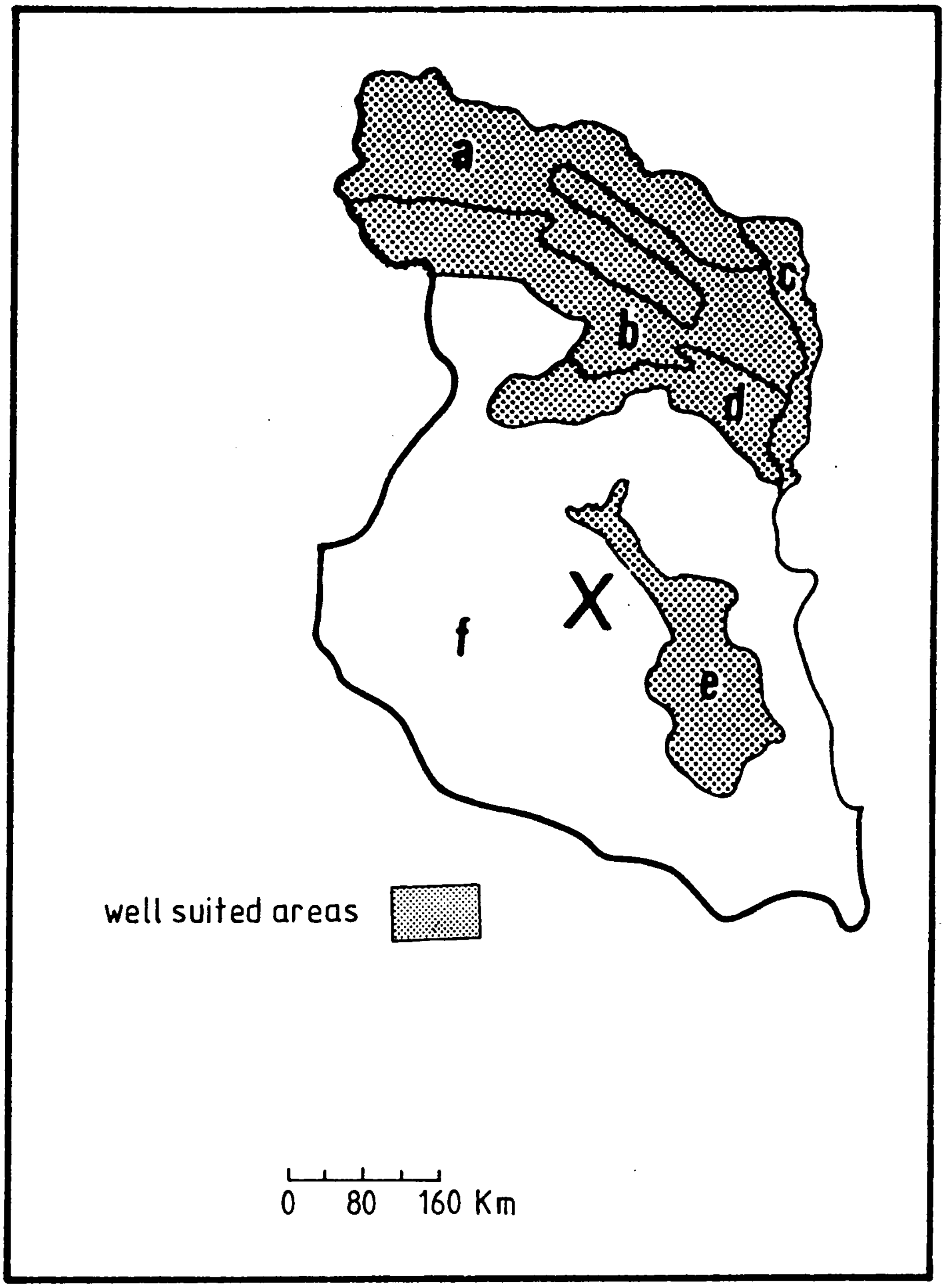


Figure 8.7 Potential areas for sugar-beet production in Khorasan extracted from the National Cropping Plan, 1975.

Table 8.9 Land under sugar-beet cultivation by region

Region	Approximate area under cultivation	%
North	41,300	59.0
Central	26,500	37.8
South	2,230	3.2
Total	70,030	100.0

Source : Ministry of Agriculture and Natural Resources, 1975.

Table 8.10 - Land under sunflower cultivation by region

Region	Approximate area under cultivation	%
North	5,900	97.2
Central	170	2.8
South	-	-
Total	6,070	100.0

Source : Ministry of Agriculture and Natural Resources, 1975.

occupies only a small proportion of the provincial sugar beet producing area total acreage of 3 per cent (Table 8.9) which is distributed solely around Birjand.

Land use pattern and zonal suitability for sunflowers: The critical planting period for sunflowers in Khorasan is between June and July and therefore it can be rotated with cereal, especially with barley which matures sooner than wheat and is thus harvested earlier, around June. Sunflowers are well suited to the northern and central areas of Khorasan (zones a, b and d), though their main concentration is in the north, which constitutes over 95 per cent of land under this crop. (Figure 8.8 and Table 8.10).

Land use patterns and zonal suitability of vegetables : The most common vegetables produced in the area are tomatoes, onions, potatoes and cucumbers. In Khorasan these are summer crops and occupy the land for relatively short periods (usually between 80 to 120 days). Thus they can be cultivated in rotation with the staple crops which take longer to mature as do wheat and barley.

From the point of view of land use suitability and potential, shown by Figure 8.9 zone 'b' is well suited to all sorts of vegetable production, partly due to the better availability of water supply and partly because this zone includes a large number of major urban centres such as Sabzevar, Torbat-e-Jam, Esfarayen, Quchan, Neyshabur, and Mashhad and thus has the greater advantage of market proximity. Among the remaining agricultural zones, zone 'a' and zone 'd' are also well-suited to production of potatoes while zone 'c' is considered to be

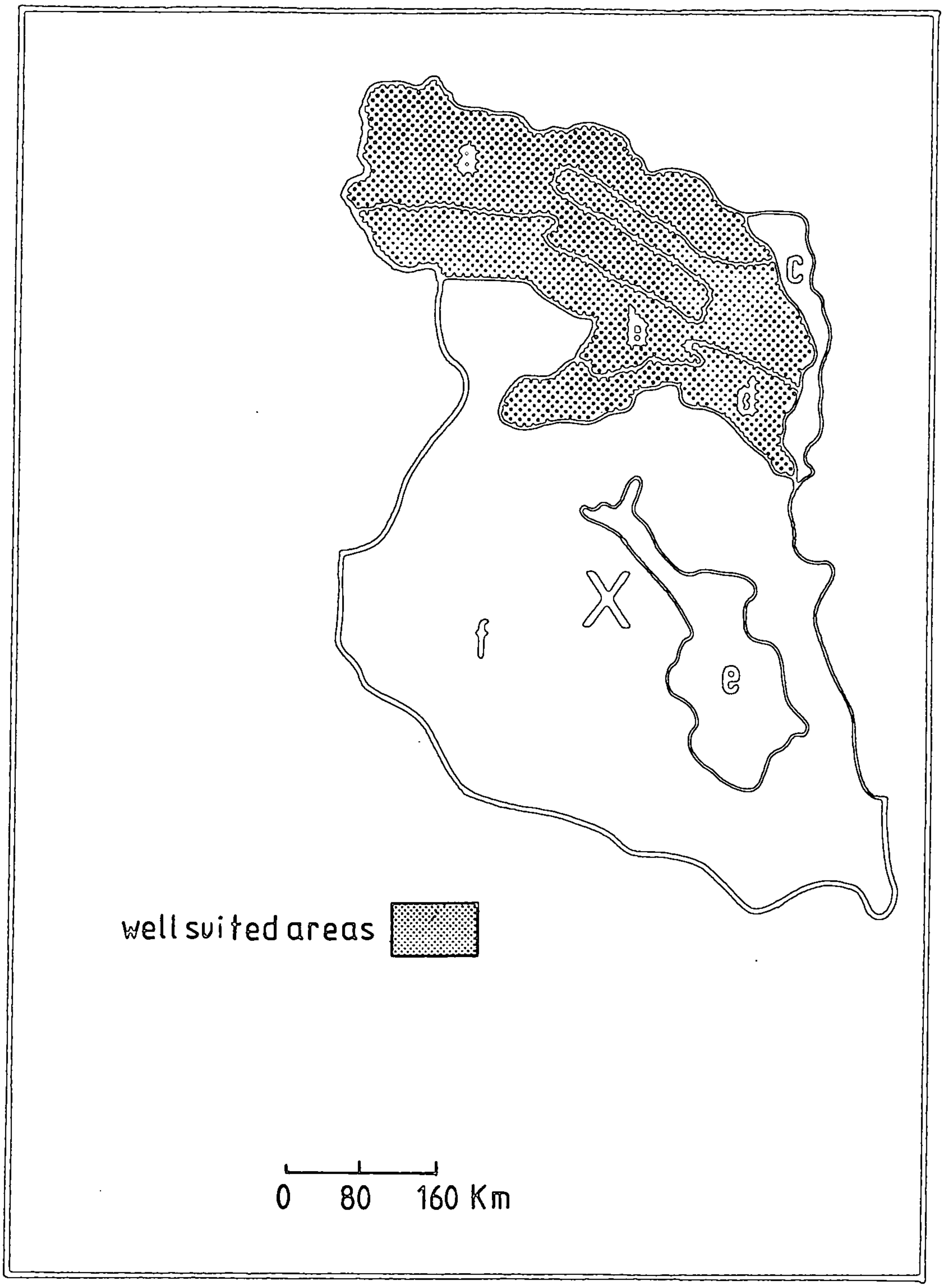


Figure 8.8 Potential areas for sunflowers in Khorasan extracted from the National Cropping Plan, 1975.

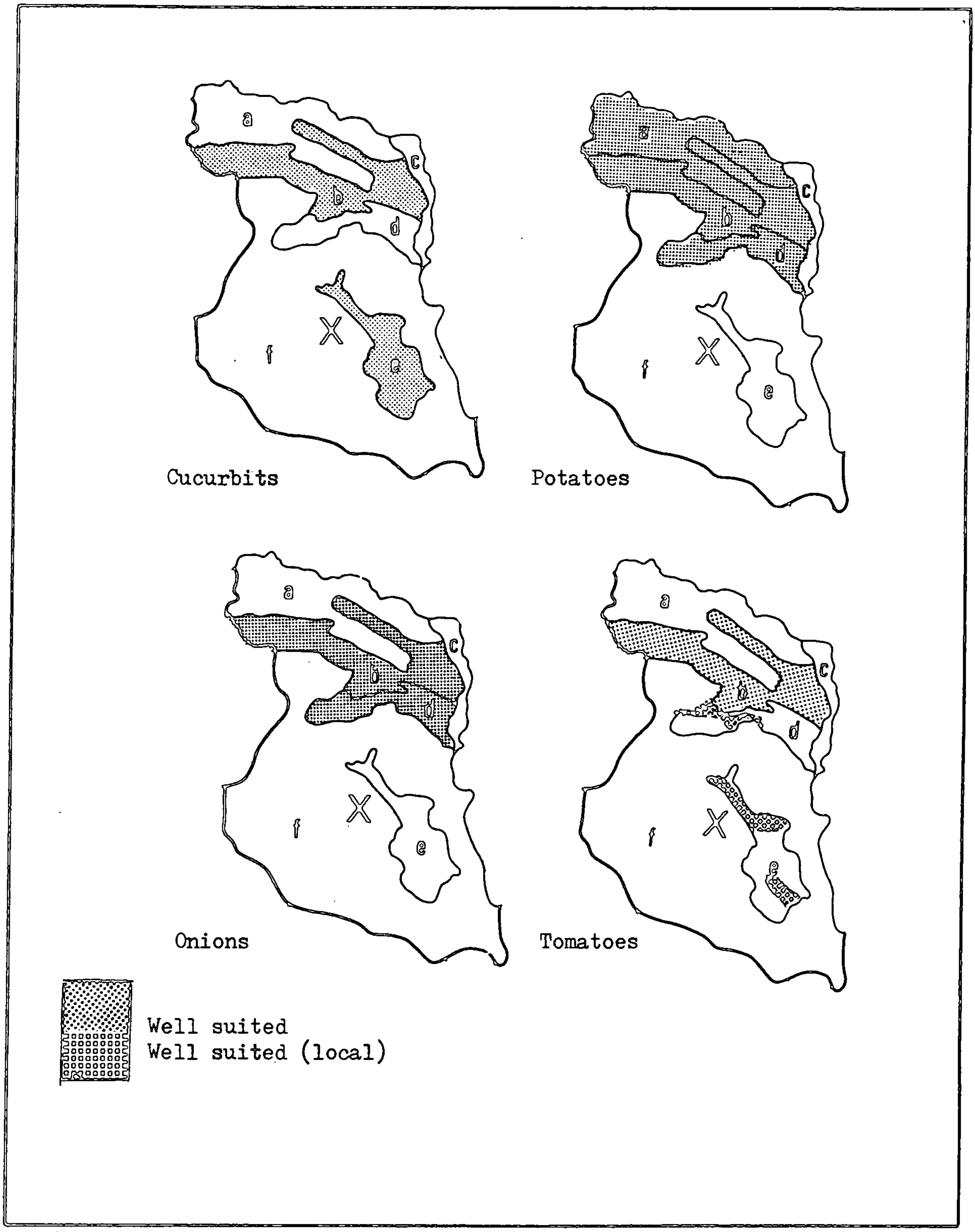


Figure 8.9 Vegetable production potentials in Khorasan extracted from the National Cropping Plan, 1975.

climatically more favourable to the production of cucurbits such as cucumbers and melons.

Among the main divisions, as shown by Table 8.11, the area north of Khorasan has the largest concentration of land under potatoes, while cucumbers and melons are much more widely cultivated in the central area.

Table 8.11. Distribution of land under cultivation of onions, potatoes and cucurbits, by region

Region	Onions		Potatoes		Cucurbits	
	Approx. cultivated area	%	Approx. cultivated area	%	Approx. cultivated area	%
North	1,005	50.3	2,710	64.5	8,350	22.0
Central	715	35.7	1,130	26.9	27,050	70.0
South	280	14.0	360	8.6	3,265	8.0
Total	2,000	100.0	4,200	100.0	38,665	100.0

Source : Ministry of Agriculture and Natural Resources, 1975.

Zonal suitability for production of deciduous fruits and grapes : The most important deciduous fruits produced in Khorasan are apples, pears, apricots, peaches and pomegranates. As can be seen from Figure 8.10, the most favourable areas for the production of deciduous fruits are zones 'a', 'b' and 'd'. The largest concentration of orchards is found particularly in Mashhad, Bojnurd, Quchan and Shirvan districts in the north. In these areas the chill winter which is followed by short spring rains and snowmelt provides ideally suited temperature conditions and water requirements for deciduous fruits. However, grapes need comparatively warmer temperatures and less chilling winter conditions,

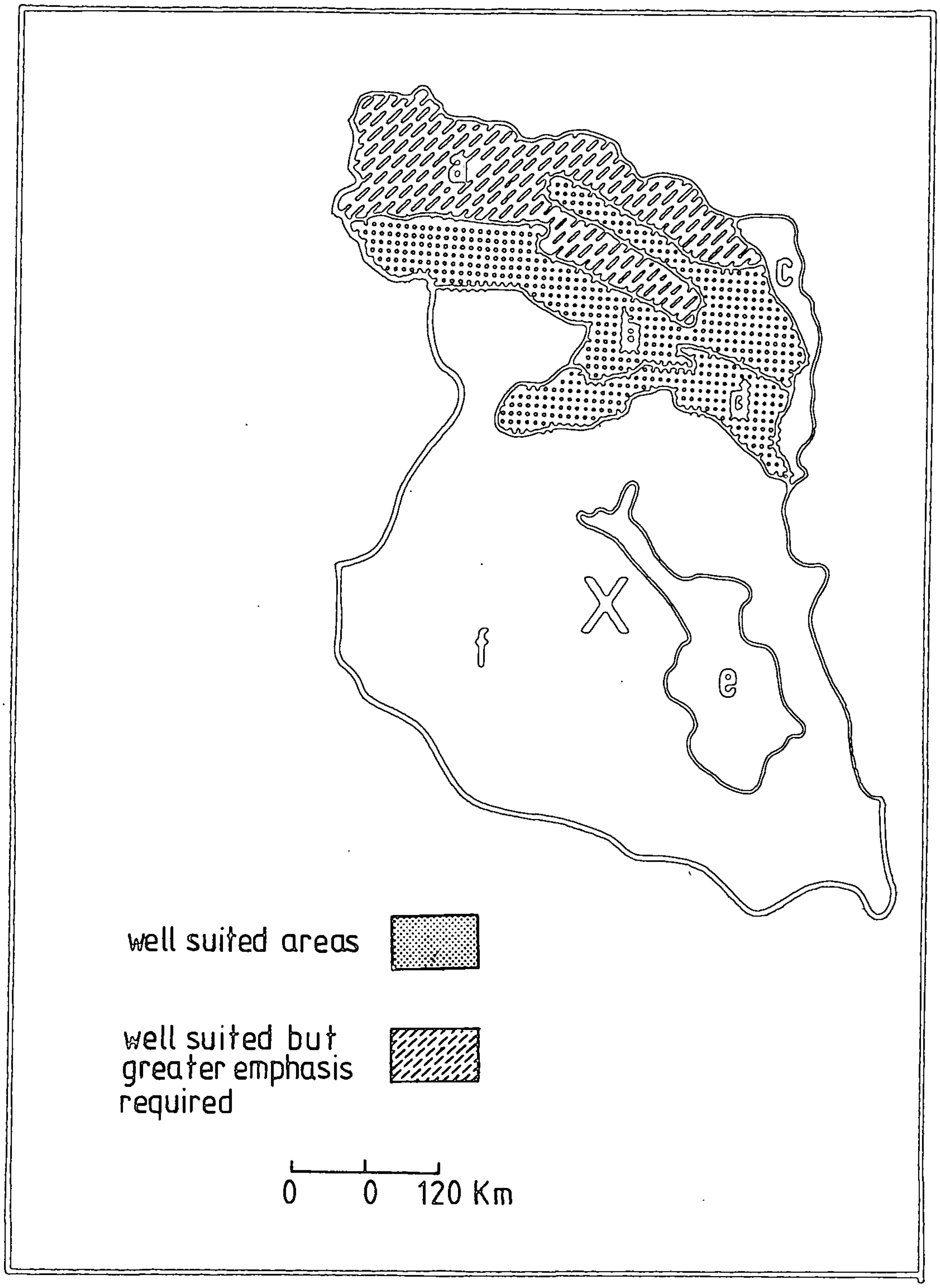


Figure 8.10 Potential fruit producing areas in Khorasan extracted from the National Cropping Plan, 1975.

and thus southern areas of Khorasan (zone 'e') and to some extent zones 'd' and 'b' are found climatically most suited for their production.

In comparison to annual crops the area under fruit trees is much smaller, but more fertile and better irrigated. Such areas are generally situated close to the villages and are commonly surrounded by walls.

Crop calendar and its effect on cropping pattern : In Khorasan crop calendars are major constraints to crop patterns in the area. The harsh long winter and late rains dictate the use of a late maturing winter cereal and thus irrigated summer crops have to be of short duration. In most parts of Khorasan winter sowing dates for wheat and barley are usually between the 30th August and the 21st November and harvesting period is between the 22nd May and the 22nd August; that gives a maximum and minimum period of maturity of 357 and 182 days respectively, or an average of 269 days. In order to grow a summer crop in most cases it is essential to obtain a minimum period of 110 days under optimum conditions (10 days land preparation, 90 days crop production, 10 days land preparation for following crops), which in fact excludes any zones where the winter crop requires more than 255 days for maturity. Thus in Khorasan major summer cropping such as sugar-beet and cotton is carried out mainly on land which has not supported a winter crop and a very high proportion of fallow (about 51 per cent of the land under cultivation) is required to accommodate the cereal/sugar beet combination which predominates. However, it should be noted that the land under wheat and barley does not always lie fallow during the summer. Whenever a village has sufficient water supply for irrigation some, or all of the land is ploughed up after the wheat and barley harvest, then sown with summer crops such as tomatoes, potatoes, onions, melons, cucumbers, lentils and chick peas, which can be matured and harvested within a short period (generally less than 120 days). However, such double cropping is limited and only practised in the villages with a good source of water supply, especially those in the vicinity of large towns.

CROP PRODUCTION

Cereal production : Despite the fact that Khorasan is traditionally the largest cereal producing area in the country (producing about 11 per cent of the national total each year), very little has been done to improve its productivity. For example, as can be seen from Table 8.12, over the years between the agricultural censuses of 1960 and 1973, while the area under wheat and barley increased by more than two fold, the increase in production was only by about 25 per cent.

The relatively poor level of increase in productivity may be an indication (a) that the land subjected to increase has been rainfed and not, more productively irrigated and (b) that the rainfed land subjected to increase has been poor quality. It is mainly for these two reasons that the production of cereal during the 1960-1973 period dropped sharply by nearly two fold (Table 8.12). Thus one can conclude that the spatial expansion of the cereal production areas of Khorasan were made for extensive rather than intensive cultivation, and the remarkable expansion of the area under wheat and barley during the 1960-1973 period did not imply a parallel increase in productivity. One factor responsible for the poor performance of these crops was undoubtedly shortage of water. With dry farming, for example, the area expanded under wheat and barley was sub-marginal lands, where the amount of

Table 8.12 Change in the land area and productivity of wheat and barley (1960 - 1973)

Crops	1960		1973		% of change in the area	% of change in production
	Cultivated area (1000 ha)	Production (1000 tonnes)	Cultivated area (1000 ha)	Production (1000 tonnes)		
Wheat	445	389	942	511	112	31.3
Barley	155	118	267	124	72.3	5.1
Total	600	507	1209	635	101	25.2

Source : Agricultural Census of 1960 and 1973

Table 8.13 Production and average yield of irrigated cereal (wheat and barley) per hectare in three main divisions, 1975

	Area under cultivation (in 1ooo ha)	% of provincial	Production (in 1000 tons)	% of provincial	Average hectarage yield in tons
North	180	38.5	243	40.4	1.35
Central	239	51.2	299	49.6	1.25
South	48	10.3	60	10.0	1.25
	467	100.0	602	100.0	1.29

Source : Ministry of Agriculture, Annual report 1976.

annual rainfall is normally less than 250 mm and subject to considerable annual variation (Chapter 3). In the traditionally irrigated cereal producing areas such as in Mashhad the problem of water shortage was aggravated by the remarkable increasing importance of sugar-beet production during the 1960-1973 period which might have resulted in low productivity and poor hectarage performance of traditional cereal crops such as wheat and barley. For example, as Flowers' work (1966) suggests, in the villages around Mashhad it has often been the case that at the time when the need for water is excessive land owners prefer to use the water for sugar-beet as it is more profitable than wheat or barley.

Salinity is also a major contributory cause of low yields in the area, especially in central and southern areas of Khorasan (see Table 8.13). However, the general effect of salinity on different crop yields will be discussed in the section on agricultural problems.

Mashhad and Quchan in the north and Torbat-e-Jam, Neyshabur and Torbat-e-Heydariyeh in the central areas are among the largest cereal producing districts, contributing about two thirds of the provincial cereal production. With the exception of Mashhad, the districts mentioned have a surplus of cereal and excess produce is usually exported to short supply regions, particularly the highly populated Mashhad district. As far as the province as a whole is concerned, considering its total population and its amount of cereal production in 1976 (this is 3.3 million and 400 thousand tons), it can be said that the region is in deficit by approximately 60 thousand tonnes (assuming a total of 200 kg as an average annual consumption per individual).

<u>Cereal Marketing</u> : Most marketing of wheat and barley is done by the larger shareholders and landowners, while small holders and peasants tend to use their share themselves for subsistence. If there is a surplus it is usually a small amount and often sold locally at harvesting time. The prices offered by local merchants are generally very low and peasants often have to accept these low prices due to their poor financial conditions, difficulties of transport, and as a consequence of not having storage facilities for later sale, as well as their general lack of business ability. The general status and the difficulties which peasants are facing in the field of marketing is well described by the following statement of Lambton (1969):

> "The amount of the crop available for sale or barter was usually extremely small. In the case of the crop-sharing peasant, his portion, after the deduction of the landlord's share and the payment of various dues, was often insufficient to maintain him and his family until the next harvest. The peasant himself performed all the operations concerned with the production and disposal of his crops. He was extremely sensitive to seasonal and other variations in price.......... Thus he was seldom in a position to drive a bargain, but was forced by need to take whatever price was offered, however disadvantageous this might be. Inadequate communications made it difficult for him to do anything but sell his goods at the nearest market. The almost permanent state of need and temporary crises which were the normal concomitant of peasant life forced him to dispose of his produce immediately after harvest, if it was not already pledged before. Barter was common, especially with travelling merchants and local shopkeepers (p.29)".

The local price of cereal (12 Rials per kg wheat and 6 Rials per kg of barley at 1975 prices) and the high cost of labour (on average 500 Rials per day at harvesting time) as well as other costs such as ploughing, seeds, fertilizer, water and irrigation give the result that the income from cereal is generally very low. However, farmers have to grow barley and especially wheat which forms a major part of their diet.

Naturally, the hectarage price and income of wheat and barley varies from one area to another, depending largely on quality and type of land under cultivation. For example, in unimproved irrigated lands (lands receiving less than an adequate supply of 6200 million m^3 per hectare) around Mashhad, the average hectarage value of wheat was about 16 thousand Rials (using the actual price in 1974), while in improved lands (lands with an adequate supply of water for full development, is with a supply of more than 6200 million m^3 per hectare), the value per hectarage of wheat was approximately 31 per cent higher (Ministry of Agriculture and Natural Resources Report, August 1975, pp.155,173). The average hectarage income of wheat and barley in various major cereal producing areas of Khorasan, using the actual farm costs and prices in 1970 (see Appendices 8.1 and 8.2). As can be seen, the average net income or the surplus of the total price value to the total cost in the case of irrigated wheat varied from the lowest of 7,230 Rials in Birjand to the highest of 9,661 Rials in Sabzevar. The gap in the average net hectarage income was higher in the case of barley, ranging between 10,730 Rials in Tabas to the lowest of 5,290 Rials in Birjand district. The variation is likely to be due to factors such as yield per hectare, quality of the product, and distance from the market. Because of overall low average income from these crops many of the traditionally cereal producing farmers, during the 1960-1975 period, turned their land over to the production of cash crops which is comparatively more profitable. This was particularly the case in the more progressive and mechanized farms in northern Khorasan, notably in Mashhad, Shirvan and Quchan, where the production of sugar-beet during the 1960-1976 period became increasingly important.

Production of sugar-beet : Sugar-beet production in Khorasan began in 1936, when the first factory was established near Mashhad. Owing to the suitability of the climate and the increase in the number of factories, the production of sugar-beet was soon encouraged and by 1966 it began to replace cotton as the most important cash crop. During the 1960-1975 period the increase in production was considerable - nearly sevenfold (see Figure 8.11).

About 60 per cent of the total sugar-beet produced in the province each year is obtained from the northern districts. Central areas constitute a smaller proportion, approximately 35 per cent and the amount in the southern areas is generally less than 5 per cent of the provincial total. Table 8.14 indicates the regional distribution of production and the number of sugar-beet factories in the area in 1974.

Table 8.14 Regional distribution of the sugar-beet factories and production in 1974

Area	No. of factories	Total production in 1000 tons	% of provincial
North	5	1,175	61.7
Central	3	689	36.1
South	1	42	2.2
Total	9	1,906	100.0

Source : Plan Organization, Annual Provincial Report, 1975. p.91.

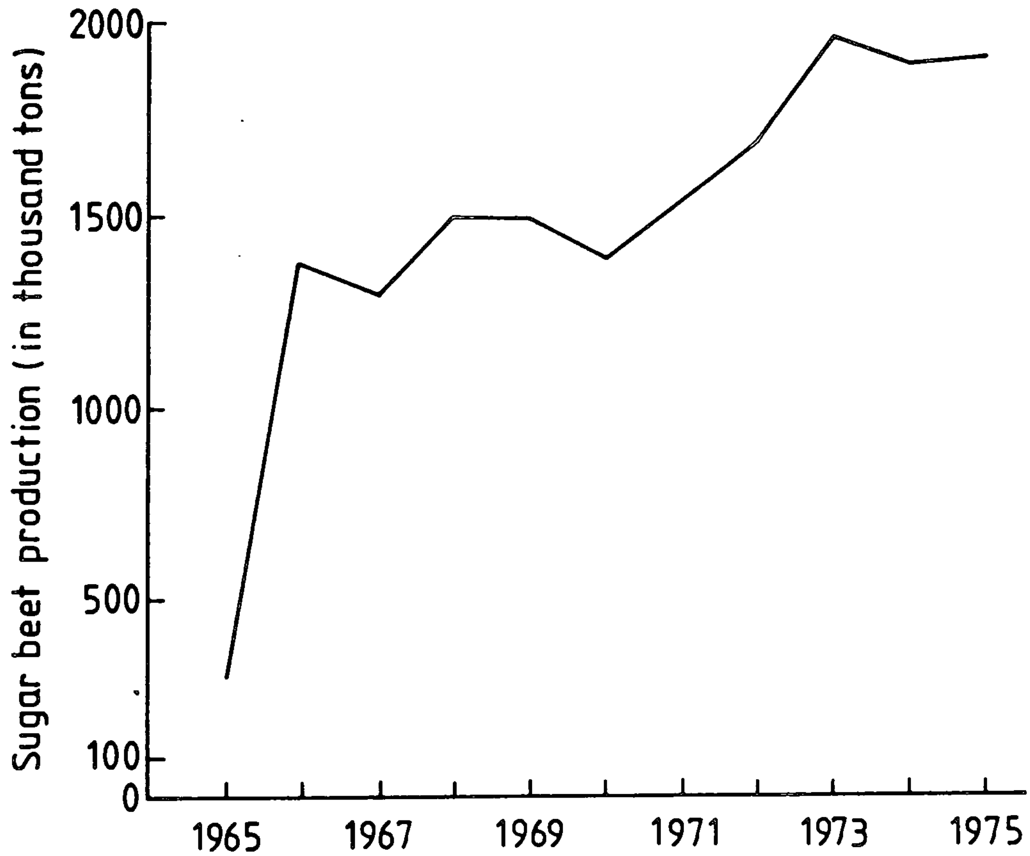


Figure 8.11 The growing importance of sugar-beet production in Khorasan between 1965 and 1975.

The average yield per hectare of sugar-beet produced in different districts of Khorasan ranges between 25 and 30 tonnes. This average, although amongst the highest in the country, is considered to be low regarding the suitability of the climate in the area. With improved seeds, technology, and fertilization it is expected that the average yield of sugar-beet should increase to about 40 tonnes per hectare by 1990 (Ministry of Agriculture, 1975, p.29).

Sugar-beet marketing and income : Beet which is produced by farmers is sold to local factories. If the contract is with the government sugar-beet factories, the beet is transported by lorries which are under contract to the factory. In such a case the factory deducts the cost of transport from the price of the beet and there is no major price variation relating to distance from the factory. With the private factories the farmers normally hire their own lorries. Naturally the cost of transport is related to distance. The longer the distance to the factory the higher will be the cost of transport per tonne. However, the higher cost of transport may be compensated by a higher price set by the factories situated at a further distance (see Figure 8.12).

The total cost, value and income per hectarage of sugar-beet among the major producing areas of Khorasan varies greatly from one area to another. For example, the total hectarage cost of sugar-beet in Birjand area was 10,750 Rials or approximately 49.4 per cent lower than in Mashhad, while at the same time because of a much lower price, average income from a hectare of sugar-beet was 7,355 Rials or 168 per cent lower (See Appendix 8.3). This indicates that the average hectarage yield in Mashhad district might have been considerably greater than Birjand. It might also be related to the better quality of the crop and

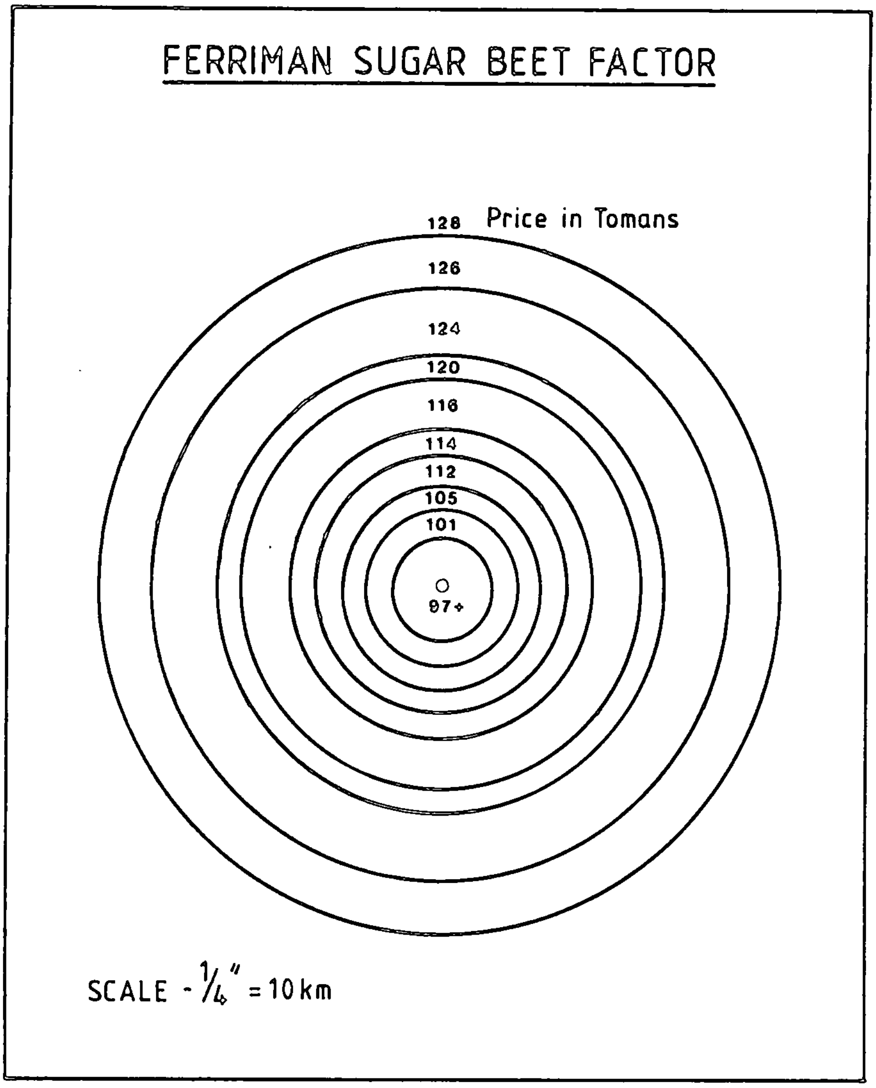


Figure 8.12 The impact of distance on sugar-beet prices. An example of Fariman. After Flower (1966).

greater marketing opportunities in the Mashhad area. In general, it can be said that it is mainly in northern Khorasan and particularly in Mashhad, Quchan and Shirvan districts that, as a result of the greater suitability of climate, better soil, greater availability of water, and marketing advantage, the economic return of sugar-beet is higher than wheat. Elsewhere in the region the return may be lower comparatively, though farmers are encouraged to produce sugar-beet largely because in comparison to wheat its income is more assured. Furthermore, factories usually provide the necessary loans for seeds, fertilizer and improvement of irrigation, as well as offering bonuses for the highest yield of beet per hectare and a cheaper price for sugar for the peasants' annual consumption. Flower (1966) described some of the advantages as follows - it is the case of the Chenaran sugar-beet factory situated some 60 km to the north west of the city of Mashhad :

> "Before the farmers actually plant their crop they are loaned, by the factory, 600 tomans for each hectare of beet to be planted. As well as this the factory sells the farmers fertilizers and will lend money for the construction of deep wells. In addition, each farmer is entitled to buy wholesale 12 kilogrammes of loaf sugar or loose sugar for each ton of beet which he sends to the factory" (p.307).

<u>Production of cotton</u> : Traditionally, the production of cotton has been one of the major sources of rural occupation and income in the area. Its importance was particularly marked at the beginning of the 20th century when there was a high demand from Russian markets (Issawi 1971, p.244). Although the rapid expansion of sugar-beet production during the 1960s and 1970s has to some extent reduced the importance of cotton

in the area, because of its relatively higher economic return, as well as by creating jobs both in the fields and local factories.
Cotton production is still of considerable importance. According to the most recent agricultural census of Iran (1982), nearly 11 per cent of total national cotton production was in Khorasan. The general trend in production level (Figure 8.13) shows that during the period 1960-76, there was a noticeable tendency towards higher production, though in later years the level of production it is reported to have declined considerably. The most important areas of production are Bojnurd in the north, and Torbat-e-Jam, Sabzevar and Neyshabur in the central division, contributing together between 60 per cent to 70 per cent of the provincial total. The important contribution of central areas of Khorasan in the production of cotton is clear from Table 8.15.

The yield per hectare of cotton is generally low being (in respect to a 1983 estimation) 1400 kg compared with about 1700 kg of the national average. Generally speaking, due to their warmer climate, the average annual yield per hectare of cotton is higher in the southern districts of Khorasan than the provincial average, whilst in the central and northern areas the average yield is lower.

Cotton income : The average income from a hectare of cotton is generally higher than the previous crops mentioned; There is a considerable variation in the cost, value and income per hectare among the various districts (Appendix 8.4). As shown, in some areas the income per hectare may be greater by two or three fold. A good example is the Torbat-e-Jam district where the average hectarage income was nearly three times higher than that of the neighbouring district of Neyshabur. One explanation may be the high quality of the crop produced in some areas which is marked by a higher price.

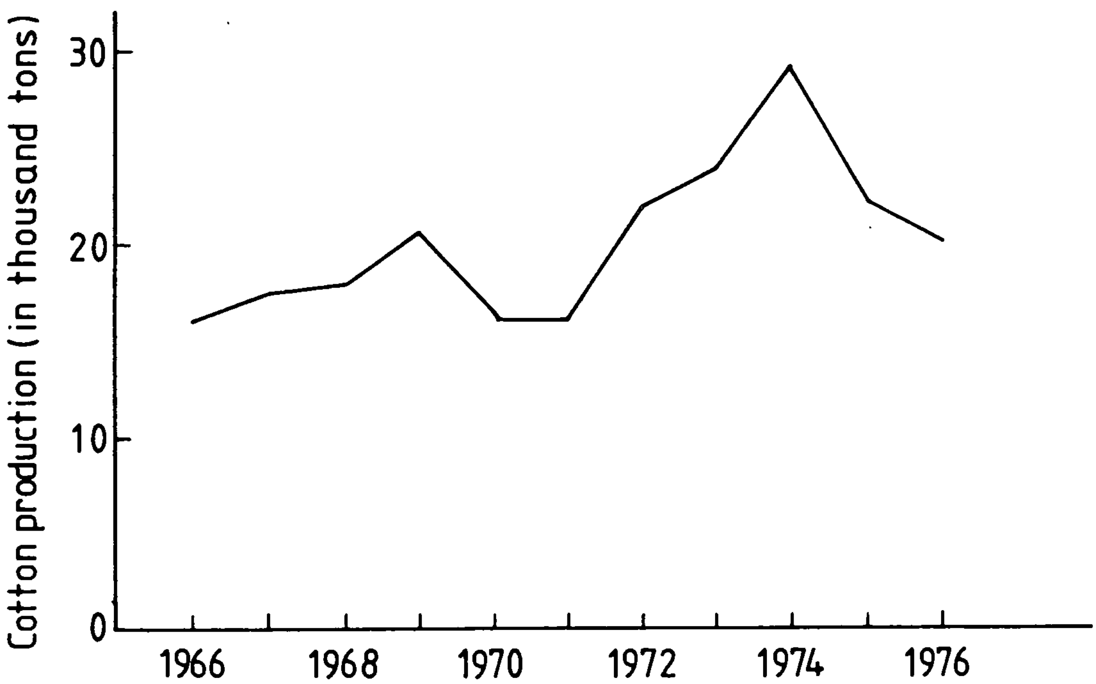


Figure 8.13 Cotton production in Khorasan between 1966 and 1976.

Table 8.15 Production level of cotton, in three main divisions of Khorasan Province in 1974

Area	Total production (in tons)	% of provincial
North	16,900	28.2
Central	34,600	57.7
South	8,500	14.1
Total	60,000	100.0

Source : Plan organization, Provincial annual reports, 1975, p.91.

Production of Melon : Various types of melon are produced in the area such as water melon (handevaneh), cantaloupes (Khasbuzeh), and honeydew (Garmak). The total production of melon in 1975 was about 248 thousand tonnes which was a noticeable increase of more than twofold compared with the production in early 1960s. The overall production increase over the mentioned period may be related to higher demand and thus higher market price and the general improvement in the conditions of roads and transport facilities. Table 8.16 shows the distribution and production of melon in Khorasan in 1974 by its major divisions :

Melon marketing and income : About 80 per cent to 90 per cent of the total melon production in Khorasan is from Mashhad, Neyshabur, Torbat-e-Jam, Sabzebar and Torbat-e-Heydariyeh. These districts are particularly famous for their production of cantaloupes. The market demand for cataloupes grown in these districts of Khorasan is usually high, and very high prices are obtained if the cantaloupes are transported to large market towns such as Mashhad and Tehran. In general it can be said that the average hectarage value of melon growing would be highly economical if communication and transport facilities were improved. At the present, because of poor communication facilities and the isolation of large market towns, by the time melons reach the markets a considerable proportion of them are damaged and regarded as third class, and therefore subjected to a very low price.

Fruit production : Fruit growing is of considerable importance in the area. It not only forms an important part of the peasant's diet, but also is a major source of cash earning, particularly in the upland areas where (a) in comparison to the lowlands the production of cereal is less extensive and (b) some major cash earning crops such as cotton are not produced.

Table 8.16 Melon production by major divisions (1974)

Area	Production (in 1000 tons)	% of provincial
North	106	22.7
Central	342	73.2
South	19	4.1
Total	467	100.0

Source: Plan organization, Provincial annual reports, 1975, p.95.

Owing to the region's remarkable climatic variation different types of fruit are produced in Khorasan. The most important ones are apples, pears, peaches, apricots and grapes. An estimated 20 per cent of the apples and pears, and about 10 per cent of the country's total apricots and peaches are produced in Khorasan (Agricultural Census of 1973). However, it is important to note that there is more variation in the productivity of tree crops than for annual crops, as fruits are comparatively more at risk from disease and insects. Moreover, their production is largely dependent on climatic conditions, for example heavy rain and hailstorms, and intensely cold periods during the spring may considerably damage the quality and reduce the yield.

The predominant contribution of the northern division in the production of various fruits produced in Khorasan is clearly shown by Table 8.17. Among the smaller divisions Mashhad's importance is by far the greatest. It alone constitutes about 75 per cent of the apple, 80 per cent of the pear, and 55 per cent of the provincial stone fruit crop production. These fruits are mainly produced in the upland villages situated along the river valleys in the northern flanks of the Binalud mountains, such as Akhlamad, Golmakan, Zoshk and Vakilabad. The other major fruit producing regions are Quchan and Kashmar which are famous for grape production and produce approximately 70 per cent of the provincial total for grapes. The only fruits which are predominantly produced in southern Khorasan (mainly in Tabas district) are dates and citrus fruits, though the production is not of significant quantities.

The suitability of the climate to deciduous fruit, better road and transport facilities and the availability of larger and closer market towns may be regarded as major factors contributing to much higher

Table 8.17 Production of major fruits produced in major divisions of Khorasan (1974)

Area	Apple		Pear		Grape		Stone Fruit		Nuts	
	Production	%	Production	%	Production	%	Production	%	Production	%
North	40,300	77.9	4,215	84.3	52,500	58.3	11,530	65.9	924	36.9
Central	11,155	21.6	741	14.8	35,900	39.9	5,470	31.3	1,280	51.0
South	295	0.5	44	0.9	1,600	1.8	500	2.8	304	12.1
Total	51,750	100.0	5,000	100.0	900,000	100.0	17,500	100.0	2,508	100.0

Source : Plan Organization, Provincial annual report, 1975, pp.98-106.

levels of production in the northern division, and in particular in Mashhad district.

Fruit Marketing and income : With the availability of large markets reasonably close by, a major production of the fruit is sold fresh. The price received for the fruit crop depends upon the quality of the fruit and the time of year when it is being sold. The price also varies according to production volume yield in the area. A remarkably high price occurs at the time when fruit crops fail. By contrast, very low prices are obtained in years of good yield. In this latter case it is common that some of the larger producers store part of their best quality surplus products for later sale in the winter when the market demand is considerably higher. According to the Ministry of Agriculture report (1975), the value of fruit from one hectare of orchard in the Mashhad area was around 100 thousand Rials (using actual prices in 1974), which in comparison to melon was nearly three times higher.

In those villages which neither produce a large quantity of fruit nor are situated at a reasonable distance from large markets, the production is normally kept by the villagers either to make jam, or to be dried and used in winter or, in the case of surplus, sold to local markets. Dried fruit has several advantages, it stores and transports easily and has a low volume/weight ratio. Besides, the market demand for some of the products such as raisins, sultanas, dried apricots and prunes is generally good.

LIVESTOCK

In Khorasan, as elsewhere in Iran, cattle, sheep, and goats have traditionally been kept and reared by the villagers and nomads for their various benefits. Their meat and milk products such as yogurt, cheese and clarified butter form a substantial part of the villagers' diet. The hair from goats and wool from sheep is used for making cloth and weaving rags and carpets. Their dung is used as fertilizer and fuel, and finally in the case of surplus, livestock products can be a source of cash earning and supplementary income for the peasants. Obviously, these products are more appreciated among the nomads and, in more arid areas of southern Khorasan where villages are more isolated and agricultural production is limited or non-existent.

The method of livestock raising varies from one area to another, depending largely on the peasant's interest and the vegetation density and availability. The most common method of livestock raising carried out in most villages during the Spring, Summer and Autumn is that the village shepherds collect the livestock (goats, sheep, oxen, cattle and donkeys) from each household in the early morning take them to pasture near the village during the day and return them to their owners in the evening. This method of grazing is particularly practised in the upland areas and nearby mountain villages. According to the Plan Organization Report (1978) almost 55 per cent of the sheep and goats in Khorasan are grazed in this way. Away from the mountain and towards the Kavir as soil quality and rainfall decreases vegetation cover becomes more scarce and sparse. As a result animals require a very large area of grazing land. Sometimes they have to be moved by the shepherds to distant pastures usually in the uplands, and are kept there for the whole summer. This method of grazing is applied to almost 36 per cent of the livestock where agriculture is practised livestock is looked after by the individual owners in the village fields. In such cases the source of grazing is fallow village land, alfalfa, forage derived from arable crop production such as hay and silage, cereal, stubble crops, wild fodder (i.e. safflower, astemesis and varieties of sedges, reed and grass), orchards, vineyards and vegetables and forage grown under the trees.

During the winter animals are kept indoors (usually in underground shelters), and are fed mainly on wheat chaff, dried grass, sugar-beet pulp, and barley. However, to cut down the expense of keeping the animals throughout the winter, rams and bullock are usually sold in the late autumn or sometimes killed for their meat to be stored and used during the winter months.

Only about 9 per cent of the livestock total in Khorasan is estimated to be raised and grazed by the nomads, using their seasonal pasturelands. The most important livestock raising nomads in the area are Sarakhsi (in Sarakhs area), Curd-e-Bojnurd and Baluch-e-Gharakhani (mainly in Bojnurd area), and Sakakhsi-e-Torbat-e-Jami (in Torbat-e-Jam area). As with other nomadic groups in the country, these nomads have their special seasonal grazing areas. Their summer stay (yeylaq) is usually in the west of Torbat-e-Jam and Sarakhs lowlands. Yeylaq lasts for a period of between 2 to 4 months, and when snow begins to fall in the mountains nomads move their herds slowly downward, grazing whatever pastures they find on their way until they come to their winter staying areas gheshlaq). After staying about 2 to 4 months in gheshlaq again they begin to move their herds towards the mountains and their yeylaq areas.

Livestock population : Table 8.18 indicates the change in the number of most important livestock in the area, between the two agricultural censuses of 1960 and 1973.

Table 8.18 Change in the number of major livestock 1960-1973

	Number in 1966	Number in 1973	% of change
Sheep	3,733,289	3,923,773	5.1
Goat	3,243,159	1,810,838	-44.2
Cattle	458,826	282,608	-38.4
Camel	14,275	13,633	- 4.5
Donkey	308,526	249,049	-19.3

Source : Agricultural Censuses of 1960 and 1973.

The number of animals mentioned in Table 8.18 indicates a noticeable decline during the 1960-1973 period, particularly in the number of goats and cattle which suffered a decline by nearly 45 per cent and more than 38 per cent respectively. This remarkable decline reflects on the one hand the severe spread of animal disease in 1963, mainly "pleuropneumonia", the 1970 drought, and 1971 harsh winter conditions, and on the other hand government policy such as protecting the pastures and changing the traditional small livestock grazing in favour of large commercial enterprises, Apart from the above mentioned disastrous cases, the number of animals and their products depends entirely on pasture conditions, and stable services. Between 80 to 85 per cent of the total of the provincial sheep and goats is distributed in the north and central areas of Khorasan, contributing as a whole about 86 per cent of the total region's pasture unit (Natural pasture as well as agricultural originating unit), while as clearly shown in Table 8.19, the corresponding proportions for the south of which includes more than half of the provincial land area, are indeed small. Poor grazing resources (only 13.7 per cent of the provincial pasture unit) and the fact that a large area of grazing land in this part of Khorasan has been transformed into protected pasture land means that animals often have to be moved a considerable distance which in view of the small and isolated nature of the villages and high cost of shepherds is not regarded as economical. Therefore villagers tend to keep and feed their animals in stables. Due to their greater adaptability to arid conditions goats and camels are the most common livestock seen in southern Khorasan, contributing about 32 per cent and 57 per cent of total provincial numbers of goats and camels respectively.

In comparison to the sheep and goats, the number of cattle in the area is much smaller, being around 400,000, of which the majority are distributed in the north where, due to higher precipitation levels, the quality and density of grass are much higher. Thus, as was shown by the map of rangeland potential (Figure 8.2), the area required to feed one livestock unit (one livestock unit is equal to one cow or seven sheep),is much smaller in the north, being in most parts between 10 to 15 hectares per composite sheep unit, while the required hectarage in the central areas is in most parts between 25 and 35 and in the south, because of the shortage of rainfall (generally less than 200 mm annually), the area required to feed one composite sheep unit is estimated to be 80 to 120 hectares and in some parts up to as much as 200 to 300 hectares (see Table 8.20).

The other important animals which are also widely found in the rural areas are donkeys and poultry. The former are used everywhere for

Table 8.19 Distribution of pasture units and livestock population (sheep and goats), by major divisions

Area	Number of sheep and goat	%	Pasture unit (in million)	%
North	4,458,800	42.9	710	33.6
Central	4,164,100	40.1	1115	52.7
South	1,759,900	17.0	290	13.7
Total	10,382,800	100.0	2115	100.0

Source : Plan organization, Socio-economic Development Plan, Khorasan Province, 1975, pp.65, 67.

Table 8.20 Area required to feed one livestock unit by major divisions

Area	Average annual rainfall (millimetres)	Number of hectares per livestock unit
North	500 - 300	10 - 15
Central	300 - 200	25 - 35
South	Less than 200	80 - more

Source : Ministry of Agriculture and Natural Resources, National Cropping Plan.

agricultural purposes such as ploughing, threshing and transport, while the latter and in particular hens, are kept for their egg yield and meat.

Livestock production : Sheep, cattle and goats are kept primarily by the villagers for their milk which is the source of dairy products such as yogurt, cheese and butter. These products, and especially yogurt, are of considerable importance in the peasants' diet, and in case of surplus are a source of cash earning. If the surplus is small and the village is isolated from a large market the surplus is sold locally whereas if the village is situated in close proximity to a large market or town then the milk surplus is sold to the village milkman who sells the product to town people or to a dairyman. Owing to the lack of commercial dairy enterprises, the low quality and intensity of the grazing land, and the inadequacy of feed which animals receive, the yield is very low. This, associated with other problems such as isolation of the villages and poor communication facilities, has resulted in the shortage of dairy products in the urban areas which therefore have to be imported from other regions and parts of the country.

The fluctuation in the number of livestock and a general decline in their population during the 1966-1977 period is greatly reflected in the animal percentage offtake of bovines, sheep, goats and thus the amount of produced meat in the area. In 1966, the total produced meat from livestock (sheep, goats, cattle and camel) was estimated to be 40 thousand tonnes, whereas in 1972, shortly after the 1970 drought and 1971 severe winter, the amount of meat produced was reduced to 22 thousand tonnes and further still to about 17 thousand tonnes by 1977, that is a drastic decline of approximately 83 per cent during the 1966-1977 period. The remarkable decline in the production of meat on one hand and the rapid increase in the population on the other have thus greatly widened the gap between the demand and supply of this product. On the basis of 1977 production and population levels and an assumed 18 kg per capita consumption, approximately nine thousand tonnes of extra meat was needed to supply the demand in the urban areas alone. Although the increased production of white meat and eggs to some extent covered the shortage of red meat, nevertheless annually a large quantity of red meat (mostly frozen) had to be imported and distributed among the cities.

The other major animal products are wool (from the sheep) and hair (from the goat) which are a source of cash earning for the peasants.

AGRICULTURAL IMPLEMENTS

Traditional agricultural tools : Khorasan is no exception to the general development taking place in the field of mechanization in Iranian agriculture. However, due to a shortage of large irrigated farms, remoteness and the small size of villages and agricultural lands, peasants in the area still do a considerable amount of farm work in the traditional way. As can be seen from Table 8.21 almost 45 per cent of the total irrigated land in Khorasan is still regarded as unmechanized, that is all production processes (ploughing, harrowing, seeding, drainage and irrigation, weeding, reaping, threshing and transportation) are done using manual labour and animal power.

Table 8.21 The extent of mechanization in rainfed and irrigated areas of Khorasan

	Total agricultural land		Fully mechanized		Semi- and part mechanized		Unmechanized	
	Area	%	Area	%	Area	%	Area	%
Rainfed agricultural area	1072.7	100.0	443.8	41.4	406.1	37.8	222.8	20.8
Irrigated agricultural area	466.9	100.0	50.2	10.8	210.8	45.1	205.9	44.1
Irrigated and rainfed total area	1539.7	100.0	494.0	32.1	617.0	40.1	428.7	27.8

Source : Ministry of Agriculture and Natural resources, National Cropping Plan, Vol.4, p.77.

In traditional farming hand tools are primitive, usually produced and repaired by the local artisans or by the farmers themselves. In most cases the hand tools used by the peasants are worn out and have not been replaced. The common tools which are used during the processes of production in each agricultural unit are the wooden or iron plough, yoke, harrow, trowel, spade, sickle, wooden fork and hook, ropes, large woollen sacks, wooden scoops and threshing sledges. Some of the tools are used in many sub-processes of production. The spade, for example, is used in different processes such as cleaning irrigation canals, ploughing, planting and gardening, while others like threshing machines are used only in certain specific sub-processes.

Because of the antiquity of the farming tools and the limitation of power sources the scale of work done by the traditional methods of farming is small. For example, the average area that one peasant and two oxen can till in one agricultural year is estimated to be limited to only 1.8 hectares while the average area tilled by one peasant driving an ordinary tractor is about 166 hectares, an increase of 92 times. Thus, it is clear that in traditional farming a large concentration of labour is required which, in turn, affects the occupation structure, size and pattern of the rural settlements.

Processes of modern agricultural machinery : The extent of mechanization in Khorasan is shown by Table 8.21. As indicated, it was only in limited areas (about 41 per cent of the rainfed and 50 per cent of irrigated cultivated lands) that full mechanization was taking place in 1972. In the remainder, the processes of agricultural production were either done entirely on traditional lines or, machinery was used only in some parts of the production process. The usual modern machinery used in semi and part-mechanized areas is the tractor used mainly for ploughing, discing and cultivating.

According to the statistical yearbook (1976), in 1972 only 22.4 per cent of the tractors, 1 per cent of the combines and 21 per cent of the other mechanical equipment were collectively owned by peasants (with the help of loans from the Bank of Agriculture), the remainder of the above mentioned modern agricultural equipment was owned by Owqhaf or were in the hands of private owners. They were either used to till their lands or rented to peasants. However, as expected most of the machinery is distributed in central and northern Khorasan where cultivation of cotton and sugar-beet are most predominant. These crops require at least partial mechanization using planters, ridgers, and lifters. In the south the process of mechanization has been slowed by the poor economic conditions of small and isolated villages and farmland.

The use of modern machinery in agriculture has several important advantages. Its greatest advantage is that it speeds up the processes of production of the crops which is an important factor in the areas where climatic conditions may permit double cropping. This matter of speeding up is particularly important in Khorasan when, as explained in Chapter 3, the harsh long winters and late rains dictate the use of late maturing winter cereals, thus leaving only a short duration for summer cropping. Obviously, with the help of modern machinery the reaping of Winter cereal and the preparation of the land for the following cropping is done in a shorter period giving a wider choice of Summer cropping in the area when climate permits.

The other important economic advantage of mechanization is that in comparison with the traditional method of farming it has proved to be more economical, it releases the peasants from the cost of keeping animals which, under the old system, were used as a power source and finally at peak times such as harvesting and land preparation for the next cropping, the use of mechanical machinery frees the peasants from reaping and ploughing and thus gives them more opportunity for other agricultural activities such as gardening and livestock herding.

However, it should be noted that the effect of mechanization on the agricultural sector is not only positive. If the change from traditional tools to modern farming machines is sudden and not proportionate to the capacity of the labour power in the area, then mechanization can have a negative effect. It may result in a large number of agricultural labourers being forced out of work, creating a problem of uncontrolled mass rural-urban migration and thus affecting the rural settlement by a formation of less compact and less populated villages. Inappropriate mechanization can also cause undue environmental pressures, such as increased soil erosion and damage to young vegetation.

The above comments lead on to further discussion about agricultural problems generally in Khorasan, as these can lead to population pressures and migration, thus disrupting settlement patterns.

AGRICULTURAL PROBLEMS

Problems of water shortage and irrigation : Like elsewhere in Iran and the Middle East as a whole, one of the most severe problems facing agricultural development is aridity and water shortage. As explained in Chapter 3, the greatest part of the region (approximately 60 per cent of the provincial area), lies within the 0-200 mm isohyets which is insufficient for dry farming. With the exception of the small area of Bojnurd in the north west which receives between 300 to 500 mm annually. The remaining areas (namely the Kashaf Valley in the north east, mountainous areas of central Khorasan and the Birjand and Qaen highlands in the south) receive average annual precipitations between 200 and 300 mm. With this amount of precipitation only poor crops of winter cereal can be grown under dry-farming. To obtain a better yield of cereal, or produce commercial crops which are climatically suited to the area (i.e. cotton and sugar-beet) irrigation is essential. However, as has been noted, irrigation also faces severe problems. The most critical problem is the lack of any major surface flow in the area. There is no foreign river (river originating outside the provincial boundaries) passing through the area and what rivers exist in the region are entirely dependent on what precipitation falls within their own catchment areas. Given the size of Khorasan the catchment areas of these rivers and the amount of water flowing in them are very small. Because of the low discharge and highly erratic nature of the rivers, the peasants of Khorasan, as in other arid parts of Iran, have had to utilize the groundwater resources in the area, and rely on other means of irrigation such as qanats and wells. The cost of irrigation by these systems is very high, an average of as much as one-quarter of the total value of grain crops and more than one third of fruits and vegetables (E.J. Hooglund 1982, p.93). Nevertheless, inspite of the great expense of constructing wells and the upkeep of many thousands of irrigation networks in the area, the water available does not meet the agricultural needs. The surface water, because of its unsuitability, described above, has only a limited potentiality for irrigation and in the case of groundwater resources only a few plains, namely Sarakhs, Esfarayen, Joveyn, Neyshabur, Gonabad, and Torbat-e-Jam may offer some additional potential ranging between 20 to 40 million m^3. Some of the plains have already over-exploited their groundwater resources. A good example is the Mashhad plain which is heavily dependent on its production of cash crops. As shown in Table 8.22, the approximate amount of water required for the cultivation of one hectare of cash crops such as cotton, sugar-beet and fruits is comparatively high.

The table indicates that the amount of required water for one hectare of sugar-beet is almost three or four times greater than for subsistence crops such as wheat and barley. The remarkable increase of over 200 per cent in the hectarage of sugar-beet between 1960 and 1970 can therefore be considered as one major factor contributing to the continuous drop in the level of the water table in the area. Figure 8.14 clearly demonstrates how the rapid increase in the production of sugar-beet during the decade between 1960 and 1970 has affected the volume discharge of wells in Mashhad area.

Table 8.22 Estimated amount of water required for the cultivation of one hectare of some selected crops in Mashhad Plain (m^3)

	O	N	D	J	F	M	A	M	J	J	A	A	Total
Wheat	800	-	-	-	-	600	-	1200	600	-	-	-	3200
Barley	-	800	-	-	-	600	600	1200	-	-	-	-	2600
Sugar-beet	-	-	-	-	-	800	-	1000	2100	2100	1800	1200	9000
Sun flower	-	-	-	-	-	-	-	800	1400	1400	600	-	4800
Melon	-	-	-	-	-	-	600	800	1000	1000	800	-	4200
Apple	600	-	-	-	-	-	700	800	1000	1200	1000	700	5800

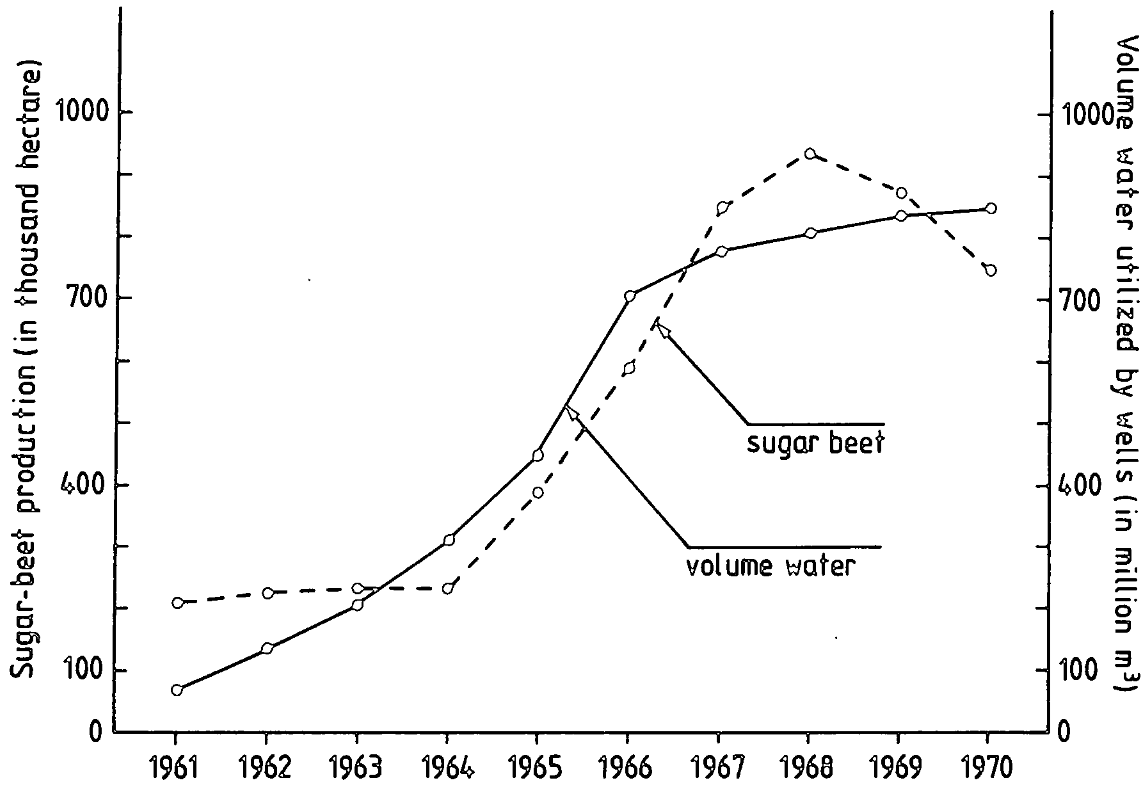


Figure 8.14 The impact of sugar-beet production on well water utilisation in Khorasan (Plan Organisation, 1974).

<u>Salinity and its problem for agricultural production</u> : On the basis of Dewan and Famouri's investigation (1964), approximately 6,330 thousand hectares or about 20 per cent of the total land area of Khorasan is covered by highly saline soils which are of either little or no value to agriculture. The approximate extent of these soils in Khorasan is as follows:

Soils association	Area in thousand hectares	Percentage
Saline alluvial soils	1100	3.51
Solonchak and solonetz soils	830	2.65
Salt-marsh soils	1600	5.11
Highly saline desert soils	1400	4.47
Calcareous lithosoils (from saliferous and gypsiferous	1400	4.47
	6330	20.21

Evaporation, low annual rainfall, as well as the conditions of the groundwater table, are important factors in the development of saline land in Khorasan. In the marginal areas and the lower parts of the basins, especially in more arid and hot regions of central and southern Khorasan, the water table is usually found close to the surface. As a result of capillary action the close sub-surface water comes to the surface and after evaporation leaves a highly significant salt deposit on the surface.

Figure 8.15 shows the effects of increasing concentrations of salinity on the yields of a variety of crops. It can be seen that this factor could have a major influence in the choice of crops in saline

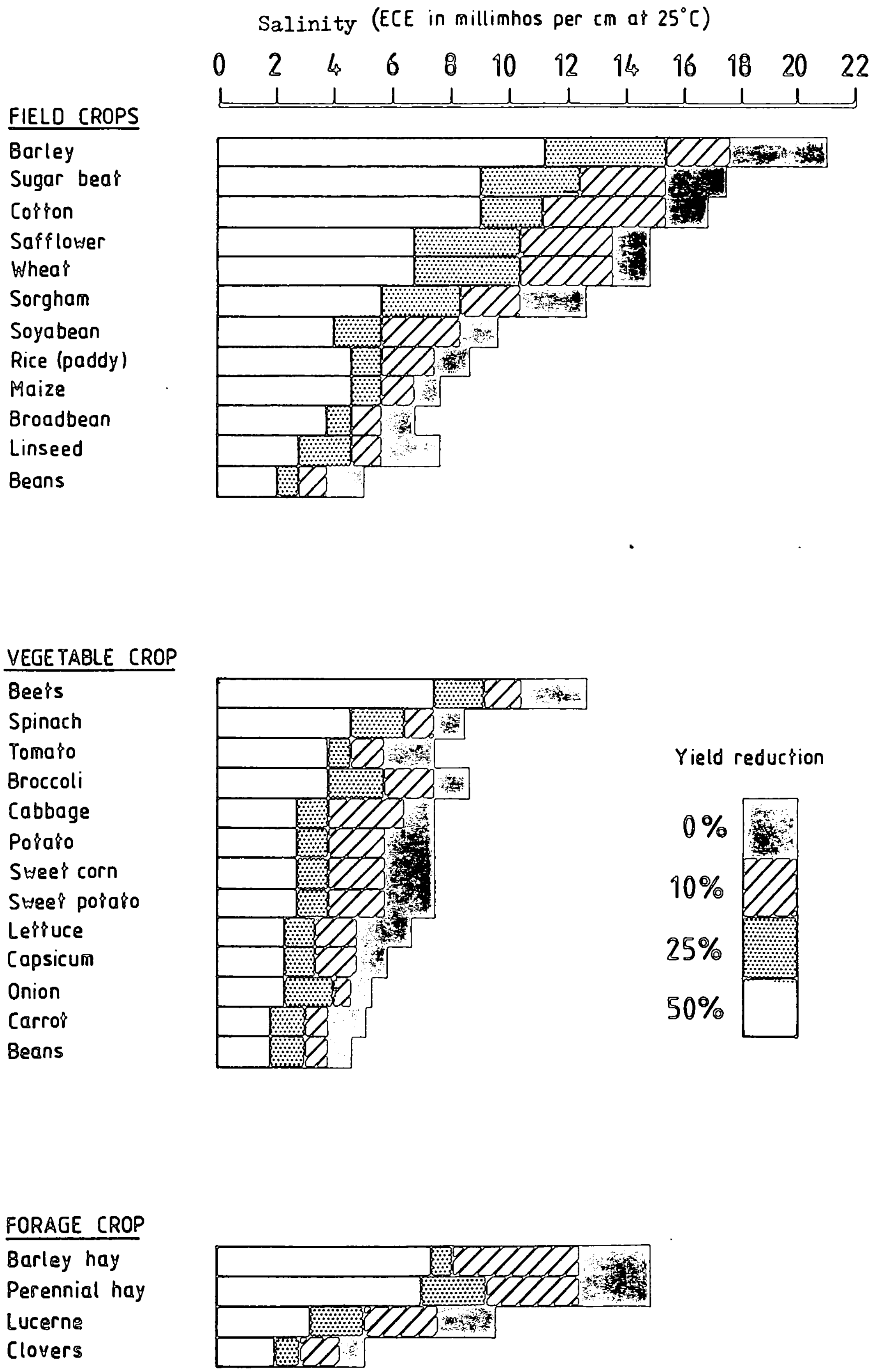


Figure 8.15 The impact of salinity on crop yields (based on the National Cropping Plan, 1975).

areas. In Khorasan, due to its vast area of saline land, this effect is clear for as was discussed in the earlier parts of this chapter, the most widely cultivated crops in the area are cereal, sugar-beet and cotton which, as seen in the Leon Bernstein investigation (Figure 8.15) have a greater salt tolerance. Nevertheless, in the marginal areas of the south and the lower parts of the basins of central Khorasan with poor drainage there are vast saline areas which are left uncultivated mainly because of the insufficiency of water for leaching and the fact that reclamation of these soils is expensive and the yield produced after the reclamation is, for the most part, low.

Problem of communication : From the communication point of view Khorasan is one of the most backward regions of Iran. The overall small size of the villages and their isolation associated with physiographical barriers such as vast deserts and numerous mountains has made the communication in the area extremely difficult. The shortage and bad condition of the roads is also an additional obstacle to the problem of communication. The total length of the roads in the area is nearly 5000 km that is only 62 metres per square kilometer. The situation is particularly critical in rural areas where there is only 187 meters of road available per settlement.

Table 8.23 gives the classification of rural settlements in uplands, low lands and the province as a whole according to the type of their roads in 1973. It is clear from this Table that the condition of roads is indeed poor in the rural areas. Less than 4 per cent of the total settlements in the area were connected by gravel or paved roads. In the remaining 96 per cent of villages the only connecting roads were those passable only by draught animals or landrovers. In the upland

Table 8.23 Classification of rural settlements according to the type of their roads in upland and lowland areas, and for Khorasan as a whole, 1973

	Lowland areas		Upland areas		Khorasan	
	Number of settlements	%	Number of settlements	%	Number of settlements	%
Roads passable by draft animals	333	4.9	2,679	33.3	3,012	20.3
Roads passable by landrover	5,829	85.5	5,153	64.1	10,982	73.9
Gravel roads	404	5.9	173	2.2	577	3.9
Paved roads	236	3.5	38	0.4	274	1.8
Railroads	15	0.2	-		15	0.1
	6,817	100	8,043	100	14,860	100

Source : Agricultural Census of 1973.

areas the gravel and paved roads are almost non existent. Due to the mountain barriers 98 per cent of the villages are dependent on the roads which in most cases are seasonal, and passable only by landrovers or draught animals.

Naturally, the poor communication system has greatly affected the economy of the rural sector in the region. Its first major economic effect is the difficulties of sending the agricultural products to the markets, thus resulting in the high cost not only in transportation, but also in damaging the products, particularly in the case of tree fruits, vegetables and melons which need to reach the market immediately after harvesting. Because of high cost and the difficulties of transport, the villages have very little motivation to produce for the market on a large scale, and thus the subsidence farming economy is encouraged in the area. This problem is particularly pronounced in the southern areas of Khorasan where the problem of more severe communications is associated with the comparatively longer distance between the villages and the large markets.

Problems of mechanization : The low level of agricultural productivity in Khorasan is, to some extent, related to factors which are obstacles to the expansion and speed of mechanization in the area. On the most important of such obstacles is undoubtedly a shortage of agricultural machinery. In 1973 for example, the total number of tractors available in the area was reported to be 4,576, while in the same year the total area of cultivated land amounted to two million hectares. That is, if we assume a total of 200 hectares as the average of work done by one tractor in one agricultural year then it is clear that for the full mechanization of the area a proportionate increase in the number of tractors will be needed.

Another major difficulty facing the expansion of mechanization is a lack of skill in maintenance and repairs. There are various makes of machinery which are imported into the area but none in sufficient quantity to warrant the setting up of a region-wide service and spare parts organization. Thus, providing the services and spare parts has become more difficult and expensive. Moreover, despite the shortage of spare parts and services, due to lack of technical advice and skilled maintenance, the machinery is not often efficiently used and therefore often falls into disrepair. For example, as shown in Table 8.24, about 5 per cent of the tractors and combines, and 17 per cent of the total available power tillers in 1973 were reported to be in a state of disrepair.

Table 8.24 Number and proportion of unusable farm machinery

	Total	Useable	Out of repair	% unusable
Tractors	4,576	4,348	228	5.0
Combines	82	68	14	17.0
Power tillers	186	176	10	5.4

Source : Agricultural Census of Iran 1974, p.83.

However, the problems of mechanization in the area are not only limited to a shortage of machinery or a lack of maintenance as discussed above. There are many other obstacles, such as small and isolated villages and agricultural lands, the poor financial status of peasants and lack of financial support by the government. The insufficiency of agricultural resources and the backward nature of the farming methods, which have undoubtedly made some contribution towards the slow process of mechanization in the area. The greatest problem is perhaps the fact that the sudden change from traditional tools to modern machines resulted in a large number of agricultural labourers being unemployed.

Fragmentation of farm lands : The minimum average area of land required to support one village family of five members on a basic subsidence level for one year is estimated to be 7 hectares. That is, taking into account that annually about one-half of the cropland is left fallow, a family will require at least 3.5 hectares of land under crops to meet its basic subsistence needs for food and commodities each year. However, as was explained in the section on land ownership (Chapter 7) in most parts of Khorasan the land which peasants bought during the land reform was less than the average seven hectares, and after was fragmented into many small pieces. In Gonabad district, for example, the average amount of land owned by each peasant's household was only 2.55 hectares and this was divided into ten plots with an average size as small as 0.26 hectares. Thus it is clear that the productivity of 2 to 3 hectares of land per household estimated for the southern districts such as Gonabad or Birjand does not fulfil subsistence needs. As a result many peasants who received such a small piece of land had either to work as labourers in the fields of those who received more than seven hectares or to leave their land and village altogether.

Limitation of land resources : Potential land resources of Khorasan are severely limited. Out of 31 million hectares of total provincial land area, only an estimated 400,000 to 500,000 hectares is annually under irrigation. Because of the shortage of water in the area the efficiency of these lands during the 1960-1976 period remains unchanged. There was not much room for future expansion or improvement either as future irrigation schemes in the area are small scale and at most can bring a further 53,000 hectares of new land under irrigation by 1993. Although, during the two agricultural censuses of 1966 and 1973, as a response to the shortage of irrigated lands and the pressure from population increase, the amount of land under dry-farming was increased two fold, owing to the low productivity of these lands the expansion did not result in any significant change in the level of productivity. Because of the extremely poor yield (about 0.2 tonnes per hectare of wheat or barley) the future expansion of these lands is doubtful. Even the present extent of dry farming land in sub-marginal areas of Khorasan is strongly recommended by government for reduction, not only because of their low level of outcome and their economic uncertainty, but also due to exhaustion of the soils which characterises many rainfed lands.

Low level of productivity : Despite the shortage of agricultural land and the immense pressure of population on potential agricultural areas of Khorasan, very little has been done to improve the level of productivity. This is clearly evident from Table 8.25 which compares the average productivity of one hectare of land for various major crops produced in Khorasan, with the national levels.

As can be seen from the table, with the exception of sugar-beet all other major crops produced in Khorasan had a noticeably lower hectarage yield in comparison to the national average. The average yields of mentioned crops common in Khorasan are particularly low when compared to some major producing North American and European countries where for example the average productivity per hectarage of wheat is about 3000 kg (nearly six times higher than Khorasan); for cotton 3000 kg (more than two times the average in Khorasan); and for sugar-beet it is about

Table 8.25 Comparison of average productivity of one hectare of land for various major crops between Khorasan and the whole of Iran

Crop	Irrigated-farming		Dry-farming		Average total	
	Khorasan	Iran	Khorasan	Iran	Khorasan	Iran
Wheat	1,389	1,455	294	474	542	718
Barley	1,234	1,445	270	502	465	699
Cotton	1,457	1,984	332	1,057	1,402	1,694
Sugar-beet	26,098	24,556	-	-	26,098	24,556

Source : Results of the Agricultural Census 1973-1974.

Table 8.26 Per capita income in rural and urban sectors of Khorasan (1967 and 1977)

Year	Rural (Rials)	Urban (Rials)	Difference (Rials)
1967	7,200	17,300	10,100
1977	9,900	24,000	14,100

Source : Plan organization, Regional Development Report, 1972, p.26.

45,000 kg per hectare (nearly two times more than the average produced in Khorasan).

One of the main reasons why the average crop yield in Khorasan are considerably lower than most parts of Iran is the limitation of physical factors such as water deficiency and soil fertility. Maximum yields are greatly dependent on soil productivity and the proper use of water. The unpredictable weather condition is also an unfavourable factor. Each year a considerable quantity of the crop is lost or damaged by floods or drought.

The very low level of productivity in the area is also related to human factors such as the backward method of the agricultural tools, low consumption of fertilizers, pesticides, insecticides, unimproved seeds, and lack of financial support.

Low level of income : The level of income in Khorasan has been one of the lowest in the country. According to the Plan Organization Report (1972), per capita income for the year 1967 was by as much as two fold smaller than national level (being 10,200 Rials in comparison to the 21,400 Rials of the national income). Similarly, there has been a remarkable difference in the per capita income between the two sectors of rural and urban. The gap for the same years of 1967 was as much as 10,100 Rials which by 1977 increased further to 14,100 Rials, as shown by Table 8.26.

The low level of income in the rural areas is to a great extent reflected by the poor performance of agricultural productivity, the stagnation of livestock activities, and the dominance of subsistence economy over the agricultural sector as a whole. However, there have also been other major influential factors which have resulted in the aggravation of the problem of low income in the rural areas, namely low investment levels, difficulties of obtaining credit supply, low prices usually paid for the crops at harvesting time, and the domination of small farm size ownership. Some of these points are explained further.

Low levels of investment and the difficulties of credit supply were common during the 1967-1977 period. For example, as shown by Table 8.27, while the contribution of agriculture to the gross provincial income was more than 46 per cent higher than the industrial sector, its share of the provincial budget for investment during the fourth development plan (1968-1973) was more than two times lower.

The supply of credit by the institutional organization (i.e. Rural cooperatives bank, Agricultural Cooperative bank and Commercial bans) were generally far less than the total requirement. For example, in 1977 the total of 328 cooperative societies in Khorasan with 345,712 members had a total capital of about 923 million Rials, that is only 2,669 Rials (about £17) per member. As a result, most of the loans had to be obtained from non-institutional private money lenders which carried very high interest rates, ranging between 24-48 per cent (Ghiassi 1972). Moreover, these loans were often short term and not totally production orientated. According to the report by the social research centre of Iran in 1967, 59 per cent of the loans given to farmers in villages near Mashhad and 70 per cent of those given in Birjand were spent on food and the remainder for the current expenditure of agriculture and water cost. These figures clearly indicate that the

Table 8.27 Contribution of various economic sectors to the provincial income and their share of the provincial investment budget

(in billion rials)

Major economic sectors	Contribution to provincial income (1967)	%	Share of provincial budget for investment (1968 - 1973)	%
Agriculture	9	34.5	4.1	12.1
Industry	6.15	23.5	8.4	24.7
Services	11.05	42.0	21.15	62.2
Total Provincial	26.2	100.0	34.0	100.0

Source : Plan organization, Regional Development Report, 1972, pp.27,28.

income of many farmers was below the subsistence level and thus the loans given to them were used for food and other subsistence commodities instead of agricultural investment.

Because of their poor financial status many of the small farmers suffered financially by having to sell their crops immediately after harvesting when, due to excess of supply, prices are at their lowest level. Small farmers, in particular, found themselves obliged to accept the low price offered by the local merchants and dealers simply because they required the harvest money immediately. Besides, they have no adequate storage facilities to store their products for later sale.

As was already explained, in most cases the amount of land which peasants received after the land reform programme was below the level of subsistence. In some districts (i.e. Gonabad and Birjand), the average hectarage of land received by the peasants was as low as 2 to 3 hectares. For many of the peasants whose total plots of land was less than the average seven hectares, the only survival was either to work as a labourer for those who received more than seven hectares, or depend on the income supplementation brought in through livestock and carpet weaving. Those without the above mentioned supplementary sources were forced to sell their land and leave their village in search of jobs. For those farmers with less than 3 hectares of land there was no, or little hope of obtaining a loan as financial institutions lending money are more willing to lend money to larger landowners who are usually more successful than to small farmers.

AGRICULTURE AND SETTLEMENT

This Chapter has shown that there are marked regional variations in agricultural efficiency and productivity in Khorasan. Not surprisingly, there is a strong relationship between these variations and settlement patterns, for example settlements are more scattered in the southern region where livestock dominate agriculture and where there is little opportunity for the growth of major agricultural centres. Conversely, the presence of large centres stimulates more intensive cultivation (allowing for physical constraints) and this allows the growth of such centres to be more self-sustaining. These points are considered further in the next chapter and in the conclusion.

CHAPTER 9 : POPULATION CHANGE

GROWTH AND CHANGE IN THE POPULATION

During the period between 1966 and 1976 many socio-economic forces combined to effect a considerable change in the population of Khorasan. The proportion of the rural population continued to fall from some 79 per cent of the total population in 1956 to 71 per cent in 1966 and to about 62 per cent in 1976 (Table 9.1). Moreover, as explained in Chapter 6, the population of rural areas has been fragmented into very small communities. For example, according to the 1976 village gazetteer data only 29 per cent of the total of 8,016 settled villages of Khorasan were classified as having more than 250 inhabitants, whereas the proportion of extremely small villages with a population of less than 100 persons was as high as 39 per cent of the above mentioned total.

In contrast to the rural, the urban population not only continued to increase considerably from some 21 per cent of the total population in 1956 to 39 per cent in 1966 and further to 48 per cent by 1976, (Table 9.1) but also showed an increasing tendency towards living in larger agglomerations. In 1956 there were 3 towns in the area with a population over 20 thousand inhabitants whereas in 1966 there were 7 and by 1976 the number rose to 11 towns. Of the major towns, Mashhad, the regional capital attracted most migrants and its population increased nearly threefold from 241,989 in 1956 to 667,770 persons in 1976. The rapid growth in the population of large towns, and particularly Mashhad, was due mainly to the growing industrialization and their increasing importance as centres of administration, transportation and commerce. In the case of Mashhad its exceptional position as the regional capital as well as being a major centre of pilgrimage was a relevant factor in its growth.

Table 9.1 Urban-Rural population change 1956-1976

Census years	Total Number of population	Urban population	%	Rural population	%
1956	2,007,581	429,925	21.4	1,577,656	78.6
1966	2,497,381	726,690	29.1	1,770,691	70.9
1976	3,264,398	1,245,258	38.1	2,019,140	61.9

Source : National Censuses of 1956, 1966 and 1976.

Population concentration and density : In general it can be said that the pattern of population concentration in the area reflects the size and pattern of settlements. That is, the most densely populated areas also have the largest settlements. However, in some parts, and despite the high concentration of villages due to their extremely small size, the overall population size is comparatively less, good examples of this being the Qaen and Birjand highlands in the south east (see Chapter 6)

A major concentration of population is particularly observable in the intermontane plains of the north where the physiographic features and the better availability of water supply and fertile soils creates better environmental conditions for agriculture. The thinly populated south is in sharp contrast and a large area of desert land is left totally uninhabited. Thus, a marked imbalance of population concentration exists between the various regions of the north and south. For example the four shahrestans of Mashhad, Quchan, Shirvan and Bojnurd forming the Atrak-Kashaf valley in the north have a combined area less than Tabas Shahrestan alone (Table 9.2). However, its population

Table 9.2 Estimated general density in Khorasan, 1966 and 1976

Area	1966		1976	
	Density	Rank	Density	Rank
Mashhad	25.7	1	39.9	1
Quchan	24.7	2	28.8	2
Shirvan	20.2	4	27.8	4
Bojnurd	10.8	7	13.7	6
Dargaz	16.8	5	13.4	7
North	20.3	-	28.1	-
Neyshabur	22.5	3	28.4	3
Sabzevar	10.2	8	12.9	9
Torbat-e-Jam	9.7	9	12.5	10
Bakhezr	-	-	13.1	8
Torbat-e-Heydar-iyeh	9.5	10	11.3	11
Esfarayen	11.1	6	13.8	5
Kashmar	8.0	11	11.1	12
Central	10.3	-	13.0	-
Birjand	2.8	13	3.3	14
Ferdows	2.2	14	2.6	15
Gonabad	6.6	12	7.8	13
Tabas	0.6	15	0.6	16
South	2.2	-	2.6	-
Khorasan	8.0	-	10.4	-

Source : National Censuses of 1966 and 1976.

density is nearly 45 times greater (Table 9.2).

According to the 1976 Census, Khorasan had a low population density of 10.4 persons per sq km. The corresponding figures for the 1966 and 1956 national censuses were naturally lower still, being 8.0, and 6.4 persons per sq km respectively. However, for a region like Khorasan where physical restraints render some two-thirds of the land area either uncultivable or uncultivated a more accurate picture of the density is obtained from the "biological density" (total population divided by the total cultivated area). Therefore if it is taken into consideration that out of Khorasan's total area, only 30 thousand sq kms (less than 10 per cent of the total provincial land area) is permanently cultivated land, then the density goes up to 109 persons per sq km on the basis of the 1976 census.

The general area, density and rank of each shahrestan in the 1966 and 1976 censuses are shown in Table 9.2. The general densities range from as high as 25.7 and 39.9 (in Mashhad shahrestan) to as low as 0.5 and 0.6)in Tabas shahrestan) in 1966 and 1976 respectively. Figure 9.1 also shows the variation for 1976.

<u>Data reliability on age and sex:</u> Owing to a lack of experience in census-taking and the very low literacy level of the population, numerous errors were found in the census figures (for example, the misenumeration of sex and some particular age groups, or the tendency for many persons to report their age as a number ending in five or zero). Nevertheless in comparison with some other population sources such as for births, deaths and migration, the statistics on age and sex are generally believed to be better in reliability and do provide

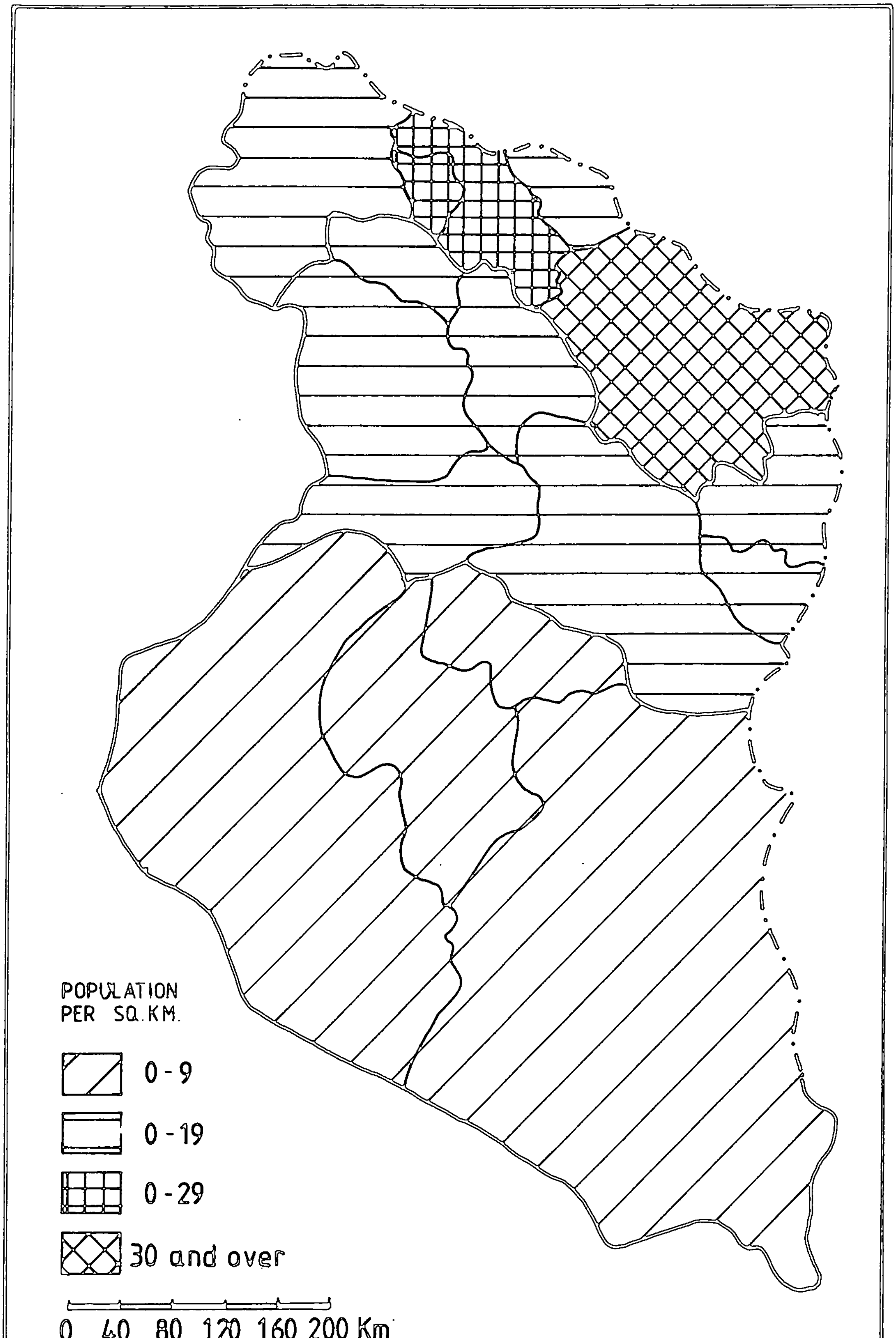


Figure 9.1 Population densities in Khorasan for 1976 (National Census).

reasonable data for tracing the study of age and sex structure of the population since 1956.

<u>Age structure of the population</u> : In common with the country as a whole, Khorasan displays a very youthful age structure. This is clearly evident from the very broad base of its pyramids of age (see Figure 9.2). Moreover, since 1956 the population of Khorasan has become remarkably younger, a fact which can be explained by the Ostan's consistent decline in the median age from 21.2 in 1956 to 17.9 in 1966, and a further decline to 17.3 by 1976. This notable fall in the median age was a direct response to the striking increase in the proportion of the population under 20 years of age, from some 49 per cent of the Ostan's total population in 1956 to 52.6 and 55 per cent in 1966 and 1976 respectively. The reasons for such a tendency seeks to be a high fertility which was accompanied by a rapid decline in infant and childhood mortality - a response to the general improvements in health and living standards throughout the country. The migration of the Ostan's population of working age to other Ostans may also be a relevant factors, for as will be seen later in this chapter Khorasan experienced a noticeable out-migration.

Due to the considerable youthful tendency it was obvious that the proportion of the adult population (15-64) would decrease. Though as data indicates (Table 9.3) this decrease was particularly marked in the first decade when the adult population dropped by some 4.2 per cent. During the second decade, however, the proportion of adults in the population increased slightly, which may be due to a decline in the trend in the proportion of children in the same decade.

Table 9.3 Age-distribution of the population for 3 selected areas 1956, 1966 and 1976

Area	Total population		Children 0 - 14		Younger adults 15 - 34		Older adults 35 - 64		Total adults 15 - 64		Elderly 65+	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
	1956											
Khorasan Ostan	2,007581	100.0	817,184	40.7	629,701	31.4	480,107	23.9	1,109,788	55.3	80,609	4
Rural Khorasan	1,577,656	100.0	647,880	41.1	486,843	30.8	376,633	23.9	863,476	54.7	66,300	4.2
Urban Khorasan	429,925	100.0	169,304	39.4	142,838	33.2	103,474	24.1	246,312	57.3	14,309	3.3
	1966											
Khorasan Ostan	2,497,38k	100.0	1,125,937	45.1	696,145	27.9	580,451	23.2	1,276,596	51.1	94,848	3.8
Rural Khorasan	2,770,691	100.0	806,259	45.5	477,999	27.0	414,723	23.4	892,722	50.4	71,710	4.1
Urban Khorasan	726,690	100.0	319,678	44.0	218,146	30.0	165,728	22.8	383,874	52.8	23,138	3.2
	1976											
Khorasan Ostan	3,264,398	100.0	1,456,507	44.6	940,816	28.8	753,805	23.1	1,594,621	51.9	113,270	3.5
Rural Khorasan	2,019,140	100.0	922,259	45.7	541,916	26.8	480,593	23.8	1,022,508	50.6	74,373	3.7
Urban Khorasan	1,245,258	100.0	534,248	42.9	398,901	32.0	273,212	22.0	672,113	54.0	38,897	3.1

Sources : 1956, 1966 and 1976 National Censuses.

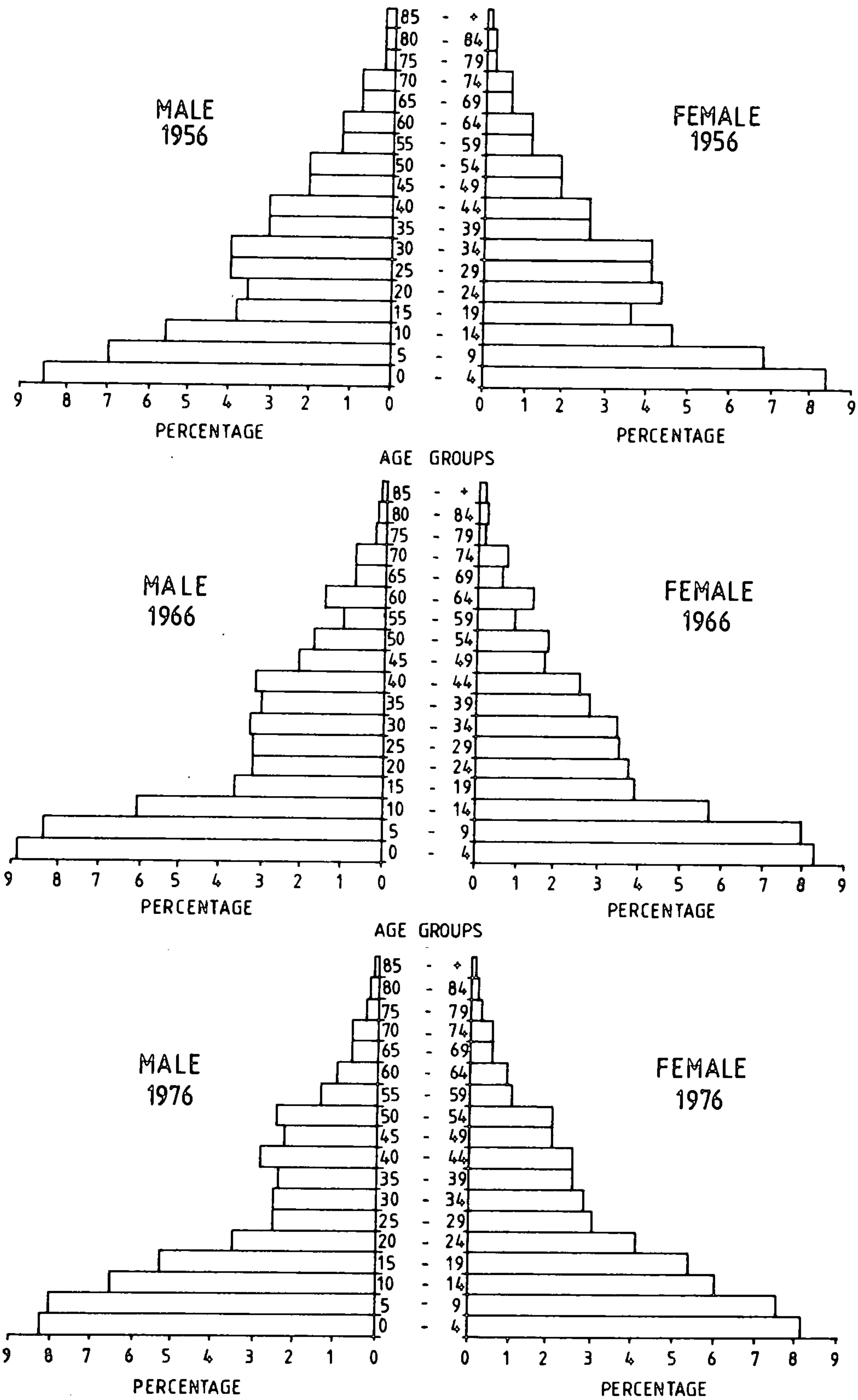


Figure 9.2 Age-Sex pyramids for Khorasan (1956, 1966 and 1976). (from National Censuses of 1956, 1966 and 1976).

As for the older sector of the population, it constituted only a small proportion of the total population. Its percentage distribution showed a declining trend from 1956, falling from 4.0 per cent of the total inhabitants in 1956 to 3.8 per cent in 1966 and to 3.5 per cent in 1976, a reflection of the growing percentage of young people in the overall age structure (See also Table 9.3).

Regional variation in the age structure: Since a majority of the population of Khorasan are still rural (61.9 per cent of the total population according to the 1976 census) the age-structure of the rural population more or less follows the same pattern of the Ostan as a whole. However, when comparing the rural age-structure with that of the urban some striking contrasts emerge in their distributional pattern. As can be seen from Table 9.3 rural areas in every census taken shared a smaller proportion of the adult age-group than did urban areas. While, by contrast it constituted a higher proportion of those in the dependent children (0-14) and dependent aged population (65+).

Several factors may be responsible for this discrepancy of rural, urban age-structure of which the most important are :

(a) fertility differences - since in the villages the marriage age is very low and birth control is not practised as it is in the towns, crude birth rate is as high as 54.8 per 1000 compared with 39.4 (estimated) for urban areas of Khorasan (Population Growth Survey of Iran, Final Report, 1973-1976, June 1978, p.67). The consequences of these fertility differences on the age structure are obvious, that is a higher proportion of youths (0-14) in the population structure. This proportion, as already referred was 45.7 per cent against 42.9 per cent in urban areas in respect of the 1976 census.

(b) migration differences - the significant effect of migration can be judged by comparing the percentage distribution of the young adult population. Table 9.3 and Figure 9.3 shows variations due to a great deal of rural outmigration in this age-group.

Table 9.4 classifies the distributional feature of the age-structure of different shahrestans according to the major age-categories of 0-14, 15-64, and 65 and over. As is evident from this table, the range of variation in the proportion of 0-14 age group (with regard to the 1976 census) was 5.7. It varied from the highest 47.2 per cent in Shirvan to the lowest 41.5 per cent in Birjand shahrestan. In the case of productive age population (15.64), the range of variation is 4.9 per cent varying from 54.2 per cent in Ferdows to 49.3 per cent in the Bakhezr shahrestan. Finally, in the percentage of those in the aged group the range did not vary more than 2.3 per cent, from the highest 4.8 per cent in Tabas shahrestan to the lowest 2.5 per cent in Shirvan.

Dependency Ratio: The dependency ratio gives the number of dependents per 100 adults of working age. It can be calculated by the ratio of the number of under 15 and over 65 years of age, to the number of persons in the age group 15-64, multiplied by 100. However, the calculation must be regarded as an approximate measure, as not all the population 15-64 years of age are economically active (for example a great number of females), and on the other hand not all the population aged 0-14 and over 65 are economically inactive.

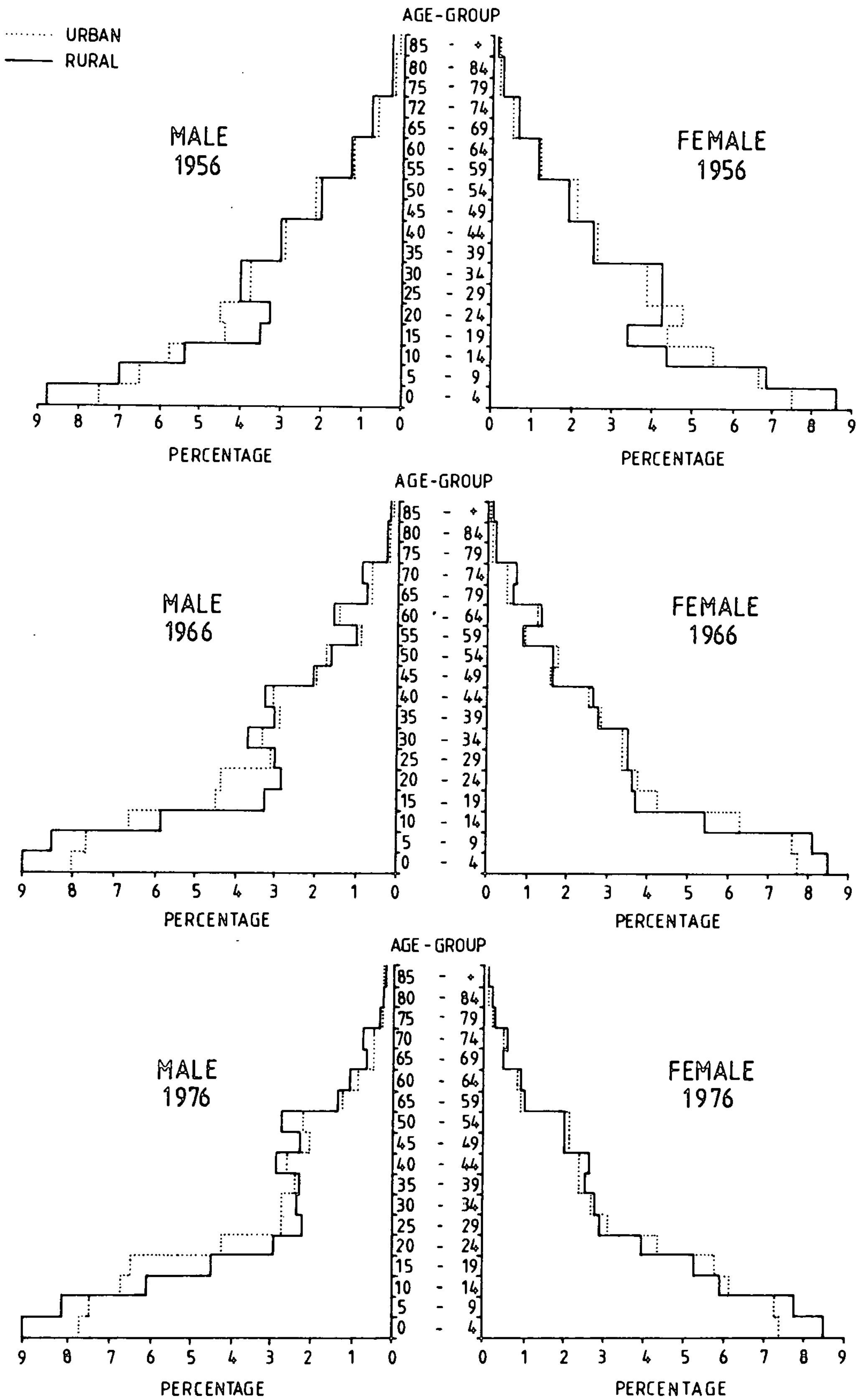


Figure 9.3 Age-Sex pyramids for urban and rural populations in Khorasan in 1956, 1966 and 1976. (from National Censuses of 1956, 1966 and 1976).

Table 9.4 Age-structure of the Khorasan Ostan by Shahrestan 1956, 1966 and 1976

Shahrestans	1956					1966					1976				
	Percentages			Dependency ratio	Median age	Percentages			Dependency ratio	Median age	Percentages			Dependency ratio	Median age
	Children	Adults	Aged			Children	Adults	Aged			Children	Adults	Aged		
Ostan as a whole	40.7	55.3	4.0	80.8	21.2	45.1	51.1	3.8	95.7	17.9	44.6	51.9	3.5	92.7	17.3
Mashhad	40.4	56.0	3.6	78.6	21.0	44.7	51.9	3.4	92.7	17.9	44.2	52.2	3.3	90.5	17.5
Sabzevar	41.0	54.9	4.1	82.1	21.3	54.1	50.7	4.2	115.0	17.9	44.7	51.1	3.7	94.7	17.1
Quchan	42.3	53.9	3.8	85.5	20.5	46.6	49.7	3.7	101.2	16.7	45.5	51.7	2.8	93.4	16.9
Neyshabur	42.3	53.8	3.9	85.9	20.4	46.1	50.1	3.8	99.6	17.0	45.6	51.2	3.9	95.1	16.8
Torbat-e-Haydariyeh	41.3	54.4	4.3	83.8	21.4	45.0	50.9	4.1	114.1	18.0	45.2	50.8	4.0	96.8	17.2
Birjand	37.6	56.5	5.8	70.7	23.1	41.7	53.5	5.0	87.6	20.6	41.5	54.0	4.5	85.2	19.2
Bojnurd	41.9	54.7	3.4	82.8	20.9	47.0	50.0	3.0	100.0	16.5	45.5	51.8	2.8	93.2	17.0
Gonabad	38.9	56.4	4.7	77.3	22.0	44.3	51.0	4.7	96.1	18.6	44.1	51.4	4.5	94.5	17.6
Bakhezr	-	-	-	-	-	-	-	-	-	-	47.1	49.3	3.6	102.8	16.5
Kashmar	40.6	55.1	4.3	81.5	21.4	45.1	51.0	3.9	96.1	18.4	45.5	50.7	3.8	97.2	17.0
Shirvan	-	-	-	-	-	48.0	49.1	2.9	103.7	16.0	47.2	50.2	2.5	99.0	15.9
Ferdows	35.4	59.6	5.0	67.8		42.9	52.3	4.8	91.2	20.6	41.7	54.2	4.1	84.5	18.8
Tabas	40.2	55.7	4.1	79.5	21.3	44.6	50.7	4.7	97.2	18.3	44.4	50.8	4.8	96.8	17.3
Torbat-e-Jam	41.6	54.4	4.0	83.8	21.3	45.9	50.6	3.5	97.6	17.5	45.9	50.7	3.4	97.2	16.9
Dargaz	40.1	57.2	2.7	74.8	21.5	46.2	50.4	3.4	98.4	17.1	44.8	51.9	3.3	92.7	17.2
Esfarayen	-	-	-	-	-	47.2	48.5	4.3	106.2	16.5	46.2	50.3	3.5	98.8	16.4

Sources : National Censuses, 1956, 1966 and 1976.

Because of the remarkable youthfulness of its population, Khorasan exhibits high rates of dependency. The ratios are particularly high in rural areas of Khorasan where the fertility rate is the highest in Iran (see Population Growth Survey of Iran, 1978, p.67). In regard to the 1976 Census the total dependency ratio in the rural areas was as high as 97.5 (of which 90.2 were children and youths and the remaining 7.3 were over 65 years of age), where for the urban areas it was 85.2 (79.5 were children, and 5.7 were elderly). The higher dependency ratio in rural areas was partly due to the enormous number of children in rural areas and partly due to the migration of young working age population from rural to urban areas.

Among the various Shahrestans, the total Dependency Ratio was particularly high in Bakhezr (102.8 in 1976), and Shirvan (99.0), while Ferdows (84.5), Birjand (85.2), and Mashhad (90.5) had the lowest ratios (Table 9.5).

Sex structure of the population of Khorasan: The sex structure of the population is usually examined in terms of the sex ratio, that is the number of males per 100 females. This ratio is influenced by the proportion of male births, the different mortality of the sexes, and migration.

Of the total 326,438 enumerated population of Khorasan in 1976, 1,658,308 (50 per cent) were males and 1,606,090 (49.2per cent) were females, giving a sex ratio of 103.3 males per 100 females. The corresponding ratios for the 1966 and 1956 censuses were 104.7 and 103.2 respectively. Data (Table 9.6) also show the sex ratio of rural and urban population of Khorasan by various age groups. From the available

Table 9.5 Dependency Ratios in rural, urban and the region as a whole in 1956, 1966 and 1976

	Total population	% of children (0-14)	% of Adults (15-64)	% of elderly (65+)	Child index	Aging index	Dependency ratio
Khorasan as a whole							
1956	2,007,581	40.7	55.3	4.0	0.68	0.04	0.80
1966	2,497,381	45.1	51.1	3.8	0.82	0.03	0.82
1976	3,264,398	44.6	51.9	3.5	0.79	0.03	0.92
Urban Khorasan							
1956	429,925	39.4	57.3	3.3	0.65	0.03	0.74
1966	726,690	44.0	52.8	3.2	0.66	0.03	0.89
1976	1,245,258	42.9	54.0	3.1	0.75	0.03	0.85
Rural Khorasan							
1956	1,577,656	41.1	54.7	4.2	0.69	0.04	0.82
1966	1,770,691	45.5	50.4	4.1	0.83	0.04	0.98
1976	2,019,140	45.7	50.6	3.7	0.84	0.03	0.97

Source : National Census of Population 1956, 1966, and 1976

Table 9.6 Sex ratio of the population of Khorasan, Urban, Rural and Khorasan as a whole by main and five years age groups, 1956, 1966 and 1976

1956			
Age group	Khorasan as a whole	Urban areas	Rural areas
0 - 4	100.7	99.1	101.1
5 - 9	100.6	96.7	101.6
10 - 14	117.4	105.8	121.3
Children 0 - 14	104.6	100.2	105.8
15 - 19	102.6	100.3	103.4
20 - 24	81.3	95.7	76.9
25 - 34	94.6	94.9	94.5
35 - 44	117.3	110.2	119.2
45 - 54	107.9	100.2	110.2
55 - 64	110.8	110.8	110.8
Adult 15 - 64	101.2	100.7	101.1
65 - over	121.6	110.2	124.2
All ages	103.2	100.8	103.9

1966			
Age group	Khorasan as a whole	Urban areas	Rural areas
0 - 4	107.3	102.9	108.9
5 - 9	103.9	101.4	104.9
10 - 14	106.3	104.4	107.1
Children 0 - 14	105.8	102.8	107.0
15 - 19	94.7	105.2	89.7
20 - 24	87.1	115.6	74.9
25 - 29	87.4	93.1	85.2
30 - 34	101.2	99.6	101.8
35 - 39	108.5	102.9	110.8
40 - 44	125.4	123.8	125.9
45 - 49	128.6	129.6	128.2
50 - 54	101.1	106.5	102.3
55 - 59	115.9	105.5	120.1
60 - 64	113.9	116.8	112.9
Adults 15 - 64	102.4	107.6	100.2
Elderly 65 over	125.1	121.8	126.3
All Ages	104.7	105.9	104.2

1976			
Age group	Khorasan as a whole	Urban areas	Rural areas
0 - 4	106.1	104.2	107
5 - 9	104.6	103.3	105.4
10 - 14	107.5	111.7	104.7
Children 0 - 14	106.0	106.1	105.8
15 - 19	98.3	117	86.1
20 - 24	84.7	98.9	75.2
25 - 29	83.1	91.5	77.6
30 - 34	93.6	102.2	88.2
35 - 39	96	101.3	92.8
40 - 44	111.7	111.9	111.1
45 - 49	112.2	109.4	113.8
50 - 54	125.2	122.1	126.9
55 - 59	132.9	127.6	136.1
60 - 64	108.5	103.2	111.3
Adults 15 - 64	99.8	107.3	95.2
Elderly 65 over	122.6	108.2	131.0
All Ages	103.3	106.9	101.1

Source : National Censuses of 1956, 1966 and 1976.

data it is possible to derive the following major points :

i) In 1976, unlike the two previous census, the sex ratio of the population in the 0-14 age group in the rural areas was less than the ratio for the urban areas. The less pronounced ratio of males over females of 0-14 age group in the rural areas reported in 1976 could be due to fewer male births, or due to a less exact assessment of the females.

ii) As a result of marked migratory factors, there has been a remarkable variation in the sex ratio of adult age groups between the two sectors of rural and urban. This is particularly so among the younger adults, notably the 15-24 age groups. In the case of the 15-19 age group, for example, the ratio was 117 per 100 females in urban areas compared with 86.1 in the rural sector. Moreover, as is also shown by Table 9.6 the sex ratio of the population of the adult age group (15-64) has decreased considerably indicating the importance of rural-urban migration since 1956.

POPULATION GROWTH AND RURAL-URBAN MIGRATION

Assuming an absence of rural to urban migration and evenly distributed growth between the two census decades of 1956-1966 and 1966-1976, the villages of Khorasan would have had an expected natural increase of 2,174,370 and 2,440,416 in the mentioned respective census periods (due to lack of information and inadequate statistics on birth and death rates it is not possible to differentiate between the natural increase in Khorasan's urban and rural areas, the calculation here is based on 32.6 rate estimated for Khorasan region as a whole by the population growth survey of Iran conducted during 1973-1976). But the actual increase of rural population of Khorasan was infact smaller by 596,714 in 1966 and by 669,725 in 1976. This difference can therefore be attributed to migration. Naturally, a total of 1,266,439 outflow from the villages within the relatively short time between 1956 and 1976 must have had a considerable impact upon the size and composition of the population in the villages, their labour force and production, and thus upon their formation and pattern. In the following section the main purpose is to explain these influential factors, but first it is essential to study the migration status of the region as a whole and to explain the pattern and characteristics of migrants in the area. The study is based mainly on lifetime migration data. This data is based on place of birth and residence at the time of the census taking years and it is not considered to be comprehensive. It does not provide information about the total number of moves made by individuals between the birth and the date of data collecting and therefore it can be said that lifetime migration data always underestimates the actual migration rates and is of little use for measuring the annual rates.

Migration status in Khorasan as a whole : Table 9.7 shows the lifetime migration status for the Khorasan region in 1956, 1966 and 1976. This table indicates that at the times when censuses of population were conducted 6.4 per cent, 7.4 per cent and 9.6 per cent respectively of the total population of Khorasan were classified as migrants, in other words were not living in the district or shahrestan of their birth. An increase of 1.0 per cent over the period between 1956 and 1966 and a higher increase of 2.2 per cent over the later decade of 1966 and 1976

Table 9.7

Migration Status in Khorasan 1956, 1966 and 1976

Year	Total Population	%	Non Migrants	%	Total Migrants	%	Born in other Shahrestans of Khorasan	%	Born in Shahrestans of other provinces	%	Born in Foreign country	%	Birth place not reported	%
1956	2,007,581	100	1,872,988	93.3	128,887	6.4	85,047	4.2	43,840	2.2	4,069	0.2	1,637	0.1
1966	2,497,781	100	2,309,704	92.5	184,379	7.4	125,164	5.0	59,215	2.4	3,298	0.1		
1976	3,264,398	100	2,937,918	90.0	312,568	9.6	212,798	6.5	99,770	3.1	13,912	0.4		

Source : National Censuses of Iran, 1956, 1966 and 1976

Region	In-migrants		Out-migrants		Net migration
	Number	%	Number	%	
Markazi	6,758	15.4	49,338	56.2	-42,580
Gilan	2,159	4.9	1,358	1.5	+ 801
Mazandaran and Gorgan	4,308	9.8	16,151	18.4	-11,843
East Azarbayjan	5,858	13.4	226	0.3	+ 5,632
West Azarbayjan	295	0.7	1,346	1.6	- 1,051
Kermanshah	1,406	3.2	2,604	3.0	- 1,198
Kurdestan	125	0.3	53	0.1	+ 72
Khuzestan and Lorestan	1,105	2.5	3,550	4.0	- 2,445
Fars and Banader	854	1.9	5,462	6.2	- 4,608
Kerman	3,984	9.1	1,317	1.4	+ 2,667
Esfahan and Yazd	10,366	23.7	911	1.0	+ 9,455
Baluchestan and Sistan	6,622	15.1	5,545	6.3	+ 1,077
Total	43,840	100	87,861	100	-44,021

Table 9.8 Migrants to Khorasan from neighbouring provinces - 1956

Table 9.9 Number and percentage of in-migrants, out-migrants, and net migration in Khorasan Province, 1966

Region	In-migrants		Out-migrants		Net migration
	Number	%	Number	%	
Markazi	12,706	21.4	98,135	51.6	-85,429
Gilan	3,133	5.3	757	0.4	+ 2,376
Mazandaran	4,080	6.9	70,253	36.9	-66,173
E. Azarbayjan	5,615	9.5	886	0.5	+ 4,729
W. Azarbayjan	849	1.4	421	0.2	+ 428
Kermanshahan	752	1.3	704	0.4	+ 48
Khuzestan	764	1.3	3,303	1.7	- 2,539
Fars	1,516	2.6	1,530	0.8	- 14
Kerman	7,110	12.0	692	0.4	+ 6,418
Esfahan	10,953	18.5	1,352	0.7	+ 9,601
Sistan-Baluchestan	6,204	10.5	7,329	3.9	- 1,125
Kurdestan	351	0.6	192	0.1	+ 159
Hamadan	883	1.5	271	0.1	+ 612
Char-Mahal and Bakhtiyari	45	0.1	24		+ 21
Lorestan	609	1.0	408	0.2	+ 201
Ilam	13	-	119	0.1	- 106
Kohkiloyeh	6	-	29	-	- 23
P.I.Persian Gulf	56	0.1	131	0.1	- 75
P.I.Oman Sea	65	0.1	199	0.1	- 134
Semnan	3,504	5.9	3,417	1.8	+ 87
Total	59,214	100	190,152	100	-130,937

Source : Plan Organization, 1972.

is consistent with the increase in the urban population by about 5.4 per cent and 5.5 per cent during the same period.

Table 9.7 also indicates that more than two thirds of the total migrants reported in the census years, were those who moved between the different shahrestans of Khorasan and nearly one third of migrants were those whose birth places were outside Khorasan's administrative boundaries. Of these, the largest contribution was from the provinces of Markazi, Esfahan and Yazd, Baluchestan and Sistan, East-Azarbayjan and Kerman. Combined, these provinces contributed to approximately between 70 to 80 per cent of the total migrants who had crossed into the boundaries of Khorasan in 1956, 1966 and 1976 respectively. (see Tables 9.8 and 9.9). In the case of the province as a whole a comparison between the census figures (Table 9.10) suggests that in all census years the number of those who had crossed the boundaries of the Ostan of their birth and moved into the Khorasan Ostan has considerably out numbered those who had crossed the administrative boundaries of Khorasan and moved to other provinces of Iran. The gap has also been increasing since 1956 from a net out-migration of 44,021 in 1956 to 130,938 in 1966 and to 159,349 in 1976. Of those who left Khorasan, the majority were absorbed by the provinces of Markazi, Mazandaran, Kerman and Baluchestan-Sistan.

Table 9.10 In-migrants, Out-migrants and Net-migration in Khorasan in 1956, 1966 and 1976

Census years	In-Migrants	Out-Migrants	Net-Migration
1956	43,840	87,861	-44,021
1966	59,214	190,152	-130,938
1976	99,770	259,119	-159,349

Source : Various sources.

The fact that in Khorasan the number of out-migrants is higher than in-migrants, and has had an increasing trend since 1956, suggests that non-agricultural sectors still do not have the capacity to absorb rural migrants and it is for the same reason that the level of urbanization in Khorasan, despite its noticeable increase since 1956, is still far from the national level, being in respect of the 1976 census 38.3 per cent compared with 46.8 for the country as a whole.

Pattern and characteristics of migrants by shahrestans : As can be seen from lifetime migration data (Table 9.11), the proportion of migrants varies remarkably from one shahrestan to another. It ranges from the highest 18.9 per cent of the total population in Mashhad shahrestan to only 2.4 per cent in Sabzevar. Of the total 312,568 migrants in 1976 a great majority (77.7 per cent) were absorbed by the shahrestans situated in northern Khorasan. The proportion for the central and in particular southern shahrestans was small, sharing respectively 16.3 per cent and 6.0 per cent of the above mentioned total. The corresponding proportion showed in Table 9.12 also suggests a similar pattern of migrants for the year 1966. A much higher proportion of migrants in the northern division may be explained by the following major reasons:

i) Higher level of urbanization - of the total 1,245,258 urban population of Khorasan in 1976, 871,929 or over 70 per cent were resident in the northern shahrestans. With the decreasing level of urbanization in the central and southern shahrestans (being respectively 22 per cent and 7 per cent of the total), the proportion of migrants tends to decrease.

Table 9.11 Lifetime migration by shahrestan in 1976

Area		Total population		Non-migrants		Total		Between contiguous Shahrestans		Between non-contiguous Shahrestans		Born in Foreign Countries	
		Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Mashhad	T	1097142	100	880889	80.3	206488	18.9	141128	12.9	65360	5.9	9765	0.9
	U	743245	100	550547	74.1	185242	24.9	124195	16.7	61047	8.2	7456	1.0
	R	353897	100	330342	93.3	21246	6.0	16933	4.8	4313	1.2	2309	0.7
Dargaz	T	52675	100	48769	92.6	3840	7.3	2938	5.6	902	1.7	66	0.1
	U	14049	100	12372	88.1	1666	11.9	1068	7.6	598	4.3	11	-
	R	38626	100	36397	94.2	2174	5.7	1870	4.9	304	0.8	55	0.1
Quchan	T	197975	100	187417	94.7	10363	5.2	7554	3.8	2809	1.4	195	-
	U	40301	100	35116	87.1	5070	12.6	3079	7.6	1991	5.0	115	0.3
	R	157674	100	152301	96.6	5293	3.3	4475	2.9	818	0.5	80	-
Shirvan	T	63281	100	56658	89.5	6387	10.1	5795	9.2	592	0.9	236	0.4
	U	21568	100	18240	84.6	3142	14.5	2684	12.4	458	2.1	186	0.9
	R	41713	100	38418	92.1	3245	7.8	3111	7.5	134	0.3	50	0.1
Bojnurd	T	235760	100	219359	93.0	15755	6.7	11495	4.9	4260	1.8	646	0.3
	U	52766	100	44634	84.6	8008	15.2	5141	9.8	2867	5.4	124	0.2
	R	182994	100	174725	95.5	7747	4.3	6354	3.5	1393	0.8	522	0.3
Neyshabur	T	264707	100	257151	97.1	7133	2.7	4446	1.7	2687	1.0	423	0.2
	U	72845	100	67563	9.3	5042	6.9	2924	4.0	2118	2.9	240	0.3
	R	191862	100	189588	98.8	2091	1.1	1522	0.8	569	0.3	183	0.1
Sabzevar	T	252927	100	246367	97.4	5995	2.4	2994	1.2	3001	1.2	565	0.2
	U	69562	100	65351	94.0	3978	5.7	1766	2.5	2212	3.2	233	0.3
	R	183365	100	181016	98.7	2017	1.1	1228	0.7	789	0.4	332	0.2
Torbat-e-Jam	T	104314	100	92964	89.1	11022	10.6	8047	7.7	2975	2.9	328	0.3
	U	21444	100	14994	69.9	6360	29.7	4198	19.6	2162	10.1	90	0.4
	R	82870	100	77970	94.1	4662	5.6	3849	4.6	813	1.0	238	0.3
Bakhezr	T	66361	100	60354	90.9	5939	9.0	5083	7.7	856	1.3	68	0.1
	U	11996	100	9062	75.5	2909	24.3	2239	18.7	670	5.6	25	0.2
	R	54365	100	51292	94.3	3030	5.6	2844	5.2	186	0.4	43	0.1
Torbat-e-Heydariyeh	T	269678	100	260733	96.7	8667	3.2	4538	1.7	4129	1.5	268	0.1
	U	55164	100	49677	90.1	5245	9.6	2456	4.5	2789	5.1	232	0.4
	R	214514	100	211056	98.4	3422	1.6	2082	1.0	1340	0.6	36	-
Esfarayen	T	73796	100	67591	91.6	6068	8.2	5641	7.6	427	0.6	137	0.2
	U	11361	100	9374	82.5	1922	16.9	1645	14.5	277	2.4	65	0.6
	R	62435	100	58217	93.2	4146	6.7	3996	6.4	150	0.3	72	0.1
Kashmar	T	147758	100	141471	95.7	6014	4.1	4036	2.7	1978	1.4	273	0.2
	U	31941	100	28810	90.2	2900	9.1	1985	6.2	915	2.9	231	0.7
	R	115817	100	112661	97.3	3114	2.7	2051	1.8	1063	0.9	42	-
Birjand	T	274016	100	260369	95.0	13046	4.8	4841	1.8	8205	3.0	601	0.2
	U	54609	100	44872	82.1	9297	17.1	3746	6.9	5551	10.2	440	0.8
	R	219407	100	215497	98.2	3749	1.7	1095	0.5	2654	1.2	161	0.1
Gonabad	T	70694	100	68395	96.7	2140	3.1	1460	2.1	680	1.0	159	0.2
	U	16150	100	14597	90.4	1407	8.7	996	6.2	411	2.5	146	0.9
	R	54544	100	53798	98.6	733	1.4	464	0.9	269	0.5	13	-
Ferdows	T	57183	100	55046	96.3	2070	3.6	1650	2.9	420	0.7	67	0.1
	U	16796	100	15339	91.3	1398	8.3	1083	6.4	315	1.9	59	0.4
	R	40387	100	39707	98.3	672	1.7	567	1.4	105	0.3	8	-
Tabas	T	36131	100	34385	95.2	1631	4.5	1152	3.2	479	1.3	115	0.3
	U	11461	100	10538	91.9	824	7.2	545	4.8	279	2.4	99	0.9
	R	24670	100	23847	96.7	807	3.3	607	2.5	200	0.8	16	-

Source : National Census of 1976

Table 9.12 Lifetime migration by shahrestan in 1966

Area		Total popul-ation		Non-migrants		Total		Between contig-uous Shahrestans		Between non-cont-iguous Shahrestans		Born in Foreign Countries	
		Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Mashhad	T	706553	100	588490	83.3	115934	16.4	73429	10.4	42505	6.0	2129	0.3
	U	417510	100	316736	75.9	98954	23.7	60378	14.5	38576	9.2	1820	0.4
	R	289043	100	271754	94.0	16980	5.9	13051	4.5	3929	1.4	309	0.1
Dargaz	T	78951	100	74073	93.8	4790	6.1	3822	4.9	968	1.2	88	0.1
	U	10711	100	8899	83.1	1748	16.3	1161	10.8	587	5.5	64	0.6
	R	68240	100	65174	95.5	3042	4.5	2661	3.9	381	0.6	24	-
Quchan	T	169370	100	163401	96.5	5910	3.5	3921	2.3	1989	1.2	59	-
	U	29133	100	26141	89.7	2942	10.1	1645	5.6	1297	4.5	50	0.2
	R	140237	100	137260	97.9	2968	2.1	2276	1.6	692	0.5	9	-
Shirvan	T	45940	100	41503	90.3	4386	9.6	4066	8.9	320	0.7	51	0.1
	U	10510	100	8534	81.2	1961	18.7	1790	17.0	171	1.6	15	0.1
	R	35430	100	32969	93.1	2425	6.8	2276	6.4	149	0.4	36	0.1
Bojnurd	T	186340	100	175275	94.1	10481	5.6	7826	4.2	2655	1.4	584	0.3
	U	31248	100	26209	83.9	4974	15.9	2994	9.6	1980	6.3	65	0.2
	R	155092	100	149066	96.1	5507	3.6	4832	3.1	675	0.5	519	0.3
Neyshabur	T	209582	100	205129	97.9	4383	2.1	3163	1.5	1220	0.6	70	-
	U	39719	100	37328	93.9	2353	6.0	1457	3.7	896	2.3	38	0.1
	R	169863	100	167801	98.8	2030	1.2	1706	1.0	324	0.2	32	-
Sabzevar	T	201100	100	198140	98.5	2942	1.5	1622	0.8	1320	0.7	18	-
	U	42415	100	41158	97.0	1245	2.9	599	1.4	646	1.5	12	-
	R	158685	100	156982	98.9	1697	1.1	1022	0.7	674	0.4	6	-
Torbat-e-Jam and Bakhezr	T	130482	100	120763	92.6	9719	7.4	6838	5.3	2705	2.1	-	-
	U	19896	100	14303	71.9	5561	28.0	3400	17.1	2161	10.1	32	0.1
	R	110586	100	106460	96.3	3982	3.6	3438	3.1	544	0.5	144	0.1
Torbat-e-Heydariyeh	T	227230	100	220919	97.2	6278	2.8	4446	2.0	1832	0.8	33	-
	U	35107	100	32553	92.7	2538	7.3	1630	4.7	908	2.6	16	-
	R	192123	100	188366	98.0	3740	2.0	2816	1.5	924	0.5	17	-
Esfarayen	T	59545	100	51738	86.9	7789	13.1	7518	12.6	271	0.5	18	-
	U	7183	100	5514	76.8	1655	23.0	1537	21.4	118	1.6	14	0.2
	R	52362	100	46224	88.3	6134	11.7	5981	11.4	153	0.3	4	-
Kashmar	T	106888	100	104348	97.6	2531	2.4	1970	1.9	561	0.5	9	-
	U	17065	100	15524	91.0	1541	9.0	1161	6.8	373	2.2	7	-
	R	89823	100	88824	98.9	999	1.1	809	0.9	188	0.2	2	-
Birjand	T	235074	100	229668	97.7	5361	2.3	3309	1.4	2052	0.9	45	-
	U	32272	100	28185	87.4	4066	12.6	2730	8.5	1336	4.1	21	-
	R	202802	100	201483	99.3	1295	0.7	579	0.3	716	0.4	24	-
Gonabad	T	59791	100	58199	97.3	1588	2.7	1328	2.2	260	0.5	4	-
	U	8152	100	7365	90.3	785	9.7	658	8.1	127	1.6	2	-
	R	51639	100	50834	98.4	803	1.6	670	1.3	133	0.3	2	-
Ferdows	T	47532	100	46284	97.4	1246	2.6	1041	2.2	205	0.4	2	-
	U	15893	100	15279	96.1	613	3.9	478	3.1	135	0.8	1	-
	R	31639	100	31005	98.0	633	2.0	563	1.8	70	0.2	1	
Tabas	T	33003	100	31774	96.3	1217	3.7	865	2.6	352	1.1	12	-
	U	9876	100	9293	94.1	571	5.8	421	4.2	150	1.6	12	0.1
	R	23127	100	22481	97.2	646	2.8	444	1.9	202	0.9	-	-

Source : National Census of 1966

Destination Shahrestan	Source area: Mashhad	Dargaz	Quchan	Bojnurd	Neysh-abur	Sab-zevar	Torbat-e-Jam	Torbat-e-Hey dariyeh	Kashmar	Birjand	Gona-bad	Ferdows	Qaen	Tabas	Total
Mashhad		-	5,866	1,442	3,123	2,196	2,049	9,751	3,076	5,299	4,195	-	2,580	1,724	41,301
Dargaz	624		4,705	53	505	133	30	130	48	86	97	82	25	20	6,538
Quchan	1,108	45		490	613	1,033	24	114	60	99	35	24	64	14	3,723
Bojnurd	1,413	97	4,080		296	1,346	115	309	191	327	202	25	38	45	8,484
Neyshabur	868	34	317	20		1,027		239	182	151	68	141	140	91	3,278
Sabzevar	280	5	172	211	462		36	48	170	48	45	28	35	30	1,570
Torbat-e-Jam	10,670	47	62	79	38			520		307	98	7	57	23	11,908
Torbot-e-Heydariyeh	1,147	55	56	43	168	83	107		264	467	215	70	252	54	2,981
Kashmar	382	15	20	21	86	257	26	310		160	171	120	61	290	1,919
Birjand	151	12	13	15	9	12	21	66	15		42	47	-	11	414
Gonabad	140	-	7	7	18	16	14	124	71	150		232	250	96	1,125
Ferdows	68	-	7	-	2	2	6	23	12	74	88		243	71	596
Qaen	75	6	18	9	2	4	36	37	11	-	114	30		-	302
Tabas	79	2	8	4	6	15	1	7	23	347	63	151	24		730
Total	17,005	318	15,331	2,394	5,328	6,124	2,465	11,678	4,123	7,515	5,433	957	3,769	2,469	84,909

Table 9.13. Khorasan internal migration in 1956.

Source area

Destination Shahrestan	Mashhad	Dargaz	Quchan	Shirvan	Bojnurd	Neysh-abur	Sab-zevar	Torbat-e-Jam	Torbat-e-Hey dariyeh	Esfar-ayen	Kashmar	Birjand	Gona-bad	Ferdows	Tabas	Total
Mashhad		1,024	1,438	660	1,347	1,006	487	2,693	1,271	184	410	901	191	131	176	11,919
Dargaz	1,693		123	78	265	37	18	55	41	31	31	183	10	2	5	2,572
Quchan	7,399	1,469		2,199	2,368	273	73	220	74	1,116	20	80	4	16	11	15,322
Shirvan	533	44	165		800	17	5	20	18	107	7	6	3	-	-	1,725
Bojnurd	2,172	125	277	292		34	122	158	44	573	12	76	6	6	17	3,914
Neyshabur	8,411	203	1,023	219	377		569	219	401	230	81	627	21	5	9	12,395
Sabzevar	3,603	151	324	294	825	981		144	97	5,105	195	73	31	10	166	11,999
Torbat-e-Jam	4,355	72	116	33	145	27	4		230	6	31	56	10	7	6	5,098
Torbat-e-Heydariyeh	20,706	208	135	57	691	183	39	1,857		31	441	620	118	20	21	25,127
Esfarayen	259	20	25	94	267	19	56	28	8		3	118	1	-	-	898
Kashmar	4,656	106	81	22	190	226	105	266	423	31		69	79	12	18	6,284
Birjand	11,170	185	133	77	313	183	62	699	1,127	53	172		628	205	293	15,300
Gonabad	4,790	77	47	18	140	77	37	357	498	12	182	264		184	70	6,753
Ferdows	1,247	80	13	13	64	64	31	66	113	31	251	173	150		73	2,369
Tabas	2,434	58	22	9	34	35	14	56	101	8	134	63	76	443		3,487
Total	73,428	3,822	3,922	4,065	7,826	3,162	1,622	6,838	4,446	7,518	1,970	3,309	1,328	1,041	865	125,162

Table 9.14 Khorasan internal migration in 1976.

ii) Better socioeconomic conditions - as already explained the average annual income in the northern areas of Khorasan is comparatively higher. There is also the advantage of better availability of jobs for both skilled and unskilled workers. According to the 1976 census figures 41.9 per cent of the total industrial and construction employees, and 63.4 per cent of the total services employees were concentrated in northern shahrestan.

iii) Greater need for labour in rural areas - because of its more favourable climatic condition and better availability of water resources, the agricultural activities in the northern parts of Khorasan are more extensive and especially at the times of peak labour demand (e.g. harvesting) many of the villages need to hire labour. This is particularly the case in Mashhad, Shirvan, and Bojnurd areas where commercial crops such as cotton and sugar-beet require more labour.

iv) Another major reason is that the capital city of the region is located in the north. It alone accounts for 71.7 per cent of the total migrants in the north and 55.7 per cent of the total provincial migrants in 1976.

If a movement between contiguous shahrestans is accepted as 'short-distance' and a movement between the non-contiguous shahrestans as 'long-distance' movements, then it is revealed from matrix migration data (Tables 9.13 and 9.14) that the higher proportion of movement in each shahrestan was short-distance, but with increasing distance between the shahrestans the migration tends to decrease. However, this is the case only if the important significant role of the capital city, Mashhad, is ignored. Otherwise, the important role of distance is overshadowed by the powerful attraction of Mashhad. This latter case is particularly true in the southern shahrestans where urban centres are small and isolated. For example, the total number of migrants who moved between the four southern shahrestans of Khorasan in 1966 was overtaken eightfold by those who migrated long-distance to Mashhad shahrestan (Table 9.14).

It is also clear from the migration matrix data, that there is a remarkable variation in the number of in-migrants and out-migrants between the shahrestans of northern and southern Khorasan. Of the total five shahrestans in the north, four, namely Mashhad, Dargaz, Shirvan, and Bojnurd experienced a net in-migration. The number of migrants in Mashhad shahrestan was particularly high, partly due to its outstanding level of urbanization, and partly because of its approximately 1,000 million m^3 ground-water availability per year, making irrigation possible through qanats and wells. Extensive irrigated farming of wheat, barley, cotton and particular sugar-beet was also a major responsible factor for net in-migration in Dargaz, Shirvan, and Bojnurd shahrestans.

Of the total seven shahrestans in the central areas of Khorasan only Esfarayen and Torbat-e-Jam experienced net in-migration mainly because of their high demand for labour to work in cotton cultivated lands. The remaining shahrestans of central Khorasan, (Neyshabur., Sabsevar, Torbat-e-Heydariyeh and Kashmar) experienced a considerable net out-migration due largely to their high concentration of rural population and low level of production. As can be seen from Table 9.14, of the total 55,809 who left these shahrestans in 1966, 37,376 or nearly 70 per cent were attracted to Mashhad shahrestan alone, and the other 10 shahrestans of Khorasan shared the remaining 30 per cent.

In the south a much higher proportion of out-migrants to in-migrants is particularly observable in Birjand, Gonabad, and Tabas shahrestans. As shown, their total in-flow from 14 other shahrestans of Khorasan was 5,502, while their total inflow to Mashhad shahrestan alone was 18,394 - more than three times greater. Broadly speaking two main reasons may be given for the remarkable net out-migration in the southern shahrestans of Khorasan. Firstly the very low level of urbanization, and secondly, the limited natural resources and thus low levels of productivity.

Contribution of rural migration to the growth of towns : In Khorasan, like in other regions of Iran, the period between 1956 and 1976 was one marked by remarkable population change in rural and urban areas. The harsh environmental conditions in the rural areas, together with a marked uneven distribution of income and socio-economic welfare between the villages and urban centres, resulted in a drastic shift of population from the former to latter areas. As is evident from Table 9.1, during the two decades of 1956-1966 and 1966-1976 there has been a considerable fall in the proportion of population in the rural areas while at the same time the proportion of population in the urban areas showed a significant increase. The growth rate of each of the urban centres of Khorasan and their relationship to internal migration are shown by Tables 9.15 and 9.16. In the absence of reliable data on birth and death rates, the calculation is based on the assumption of an equal rate of natural increase in rural and urban areas (a rate of 3.2 per cent estimated by the population growth survey for Khorasan region during 1973-1976). The differences between this rate and the rate of

Cities	Population in 1956	Population in 1966	Actual rate of increase	Expected 1966 population	Estimated net-Decennial migration	Geometric mean between 1956 and 1966 population	Estimated annual rate of net-migration (000)
Mashhad	241,989	409,616	5.4	333,516	+76,100	314,830	+24
Sabzevar	30,545	42,415	3.3	31,540	10,875	35,000	31
Neyshabur	25,820	33,482	2.6	26,661	6,821	29,400	23
Bojnurd	19,253	31,248	5.0	19,880	11,368	24,530	46
Torbat-e-Heydariyeh	19,830	30,106	4.3	20,476	9,630	24,430	39
Quchan	21,250	29,133	3.2	21,942	7,191	24,880	29
Birjand	13,934	25,854	6.4	14,388	11,466	18,980	60
Kashmar	13,299	17,065	2.5	13,732	3,333	15,060	22
Torbat-e-Jam	6,756	13,958	7.5	6,976	6,982	9,710	72
Ferdows	6,834	10,813	4.7	7,056	3,757	8,596	44
Dargaz	8,541	10,711	2.3	8,819	1,892	9,560	19
Shirvan	6,906	10,510	4.3	7,131	3,379	8,520	40
Tabas	7,413	9,876	2.9	7,654	2.222	8,560	26
Gonabad	7,555	8,152	0.7	7,801	351	7,850	4

Table 9.15 Contribution of net migration to urban population change in Khorasan (1956-66).

Cities (>10,000)	Population in 1966	Population in 1976	Actual rate of increase	Expected 1976 population	Estimated net-Decennial migration	Geometric mean between 1966 and 1976 Population	Estimated annual rate of net-migration (000)
Mashhad	409,616	667,770	5.0	564,544	+103,226	523.000	+20
Sabzevar	42,415	69,562	5.1	58,457	11,105	54,320	+20
Neyshabur	33,482	59,562	5.9	46,145	13,417	44,660	+30
Bojnurd	31,248	47,719	4.3	43,066	4,653	38,610	+12
Birjand	25,854	46,943	6.1	35,632	11,311	34,840	+32
Torbat-e-Heydariyeh	30,106	43,259	3.7	41,492	1,767	36,090	+ 5
Quchan	29,133	40,301	3.3	40,151	150	34,260	+0.5
Kashmar	17,065	26,883	4.7	23,519	3,364	21,420	+16
Sakhtaman	1,361	22,424	32.3	1,875	20,549	5,524	+1095
Shirvan	10,510	21,568	7.4	14,485	7,083	15,050	+47
Torbat-e-Jam	13,958	21,444	4.4	19,237	2,207	17,300	+13
Dargaz	10,711	14,049	2.7	14,762	- 713	12,270	- 6
Fariman	7,894	12,385	4.6	10,879	1,506	9,880	+15
Tayebad	5,938	11,996	7.3	8,183	3,813	8,440	+45
Tabas	9,876	11,461	1.4	13,611	-2,150	1,060	-203
Esfarayen	7,183	11,361	4.7	9,899	1,462	9,030	+16
Gonabad	8,152	10,610	2.7	11,235	- 625	9,300	- 7
Ferdows	10,813	10,226	-0.6	14,676	-4,676	10,515	-44
Torqabeh		10,101					

Table 9.16 Contribution of net migration to urban population change in Khorasan (1966-76).

actual growth of population in each urban centre is regarded as the migration rate. The calculation in Table 9.15 indicates that of the total 14 urban centres of Khorasan during 1956-1966, 5 had an annual rate of growth lower than the 3.2 per cent and therefore can be assumed to have experienced a net out-migration. The growth of one urban centre, Quchan, was 3.2 per (cent equal to the estimated provincial rate of natural increase), and the remaining eight showed a higher rate. Among the eight urban centres which experienced net in-migration Torbat-e-Jam had the highest annual rate of net in-migration with 72 per thousand, followed by Birjand with 60, Bojnurd 46, and Ferdows with 44 per thousand. Although owing to the effect of its sizeable population, the annual rate of net in-migration was not markedly high for Mashhad (24 per thousand), however, it alone accounted for 76,100 or as much as all the net migrants attracted by the remaining 13 urban centres. A much higher attraction of migrants to Mashhad can be attributed to its function as a regional capital, as a centre for pilgrimage, commerce,administration and transportation. It provides better and wider job opportunities, higher income, better amenities, and high standards of living - clear advantages which are also observable in other regional capital cities of Iran such as Tabriz and Esfahan.

A comparison between Table 9.15 and 9.16, indicates a noticeable change in the rates of net migration of the urban centres between the 1956-1966 and 1966-1976 decades. During the latter decade the number of urban centres with a population of over 10,000 increased to nineteen, of which only four showed an annual growth rate below the rate of natural increase (3.2 per cent). Three of the four urban centres which experienced net out-migration, namely Tabas with 203 per thousand, Ferdows with 44, and Gonabad with a net out-migration of 7 per thousand, are situated in the marginal desert areas of southern Khorasan. Of the remaining fifteen urban centres which had a rate of growth higher than the 3.2 per cent annual rate of increase, Sakhtaman had by far the highest net in-migration rate with 1095 per thousand, followed by Shirvan with 47 and Tayebad with 45 per thousand. During 1966-1976, the number of migrants to Mashhad increased by 27,126 compared with the previous decade, but owing to its sizable population its rate of net in-migration was smaller by four per thousand.

In general, the calculations in Tables 9.13 and 9.14 reveal two major points :

i) Despite the fact that the loss of rural population was much greater in southern Khorasan, its urban centres could not play an important role in absorbing them, and a great majority of the people who left their villages moved to other areas. This is particularly the case in low rainfall and marginal desert areas such as Tabas, Ferdows and Gonabad shahrestans. As shown by Table 9.14, the small towns in these areas have had high levels of out-migration, often in excess of the natural population increase, causing a fall in the actual net population. In the areas of Southern Khorasan, Birjand was the only urban centre which in both decades showed a net in-migration. This, however, is not surprising if one considers the fact that it is surrounded by 1999 small size inhabited villages, and is the only important and short distance urban centre available in the area.

ii) The second important point which may also be concluded from Table 9.13 and 9.14, is that unlike the small urban centres in the south, the small towns of northern Khorasan had a considerable net in-migration during the 1966-76 decade. This is particularly more significant in the case of satellite towns such as Toroq, Torqabeh, Golshahr, and Sakhtaman which have suddenly emerged around the capital city of Mashhad. The satellite town of Sakhtaman for example was virtually a village in 1966, while in 1976 its population was recorded as 22,424 inhabitants, a remarkable growth of over 1547 per cent. This, however, is an indication of the increasing important role of small towns in the north as a powerful centre for the attraction of rural migrants in the area. In fact, these satellite towns play the role of dormitory settlements for many of those whose daily work is in Mashhad. Mashhad also has a majority of low skilled jobs such as in construction, which is perhaps the only easy and readily available job for unskilled people who come from arid southern areas of Khorasan.

CONCLUDING COMMENTS

This chapter has highlighted a number of dynamic aspects of Khorasan's population such as growth, structure, and migration. Clearly these all affect the changing nature of settlements and settlement patterns and emphasises some of the points made in previous chapters. This aspect is taken further in the final chapter where settlements are considered according to areas of growth and abandonment, and also in relation to policy and planning which has existed since 1956.

CHAPTER 10:CONCLUSION

This chapter concludes the themes from the previous chapters by considering aspects of settlement location under four main headings. Firstly, the patterns of change between 1966 and 1976 are described. Secondly, some suggestions are offered to explain some of these patterns. Thirdly, one interesting symbol of the changing settlement patterns is analysed to place the earlier themes into a more specific context. Finally, this chapter returns to the themes of Chapter 1 and reconsiders some of the theoretical aspects of settlement location and theory. This is done with reference to settlement planning documents for the Khorasan region.

SETTLEMENT PATTERNS

This thesis has looked at changing settlement patterns in the Province of Khorasan as a whole, and also by examining more detailed aspects at the scale of the three major sub-divisions of 'North, 'Central' and 'South'. The most obvious features of the patterns are that settlements are both larger and more densely clustered in the north and smaller and more dispersed in the south. They also tend to accumulate along river valleys and also in the areas of higher relief, the latter especially in the south.

In terms of more-localised patterns, villages often tend to be located in a linear pattern in the north, especially along the River Kashaf to the west of Mashhad, and along the River Atrak and its principal tributaries. There is a tendency for clustering in the more central areas, which is a reflection of localised groundwater availability. Scattered patterns of villages are more characteristic of the south.

With respect to urban and settlement growth the most dramatic increases have been in northern areas, especially where cultivation opportunities have reached their maximum and people have become aware of new opportunities in urban areas. Growth is especially common in the vicinities of the principal towns such as Mashhad and Quchan, Bojnurd, Neyshabur and Sabzevar.

EXPLANATIONS OF PATTERN

The comments in the previous section have presented a crude description of settlement patterns, but offered little in the way of explanation. This has been addressed in Chapters 3 to 9 and the principal points are now summarised under three major headings; physical determinants (such as topography, climate, soil and water supply); land use determinants (such as land reform legislation and agricultural utilisation); and population determinants (especially with respect to migration).

Physical determinants: At a general level it can be seen that settlement size, density and spacing reflects, to some degree, the availability of natural resources. As several essential resources are both poor in quality and widely scattered, the settlements tend to reflect this overall pattern. Some of these resources are now reviewed more specifically.

i) Topography and Rainfall - Topography plays an important role in determining the location of settlements. At its simplest level there is a difference according to relief. Higher relief leads to higher rainfall levels and hence larger and more settlements can be sustained by the local water supply; nearly half of the settlements in Khorasan are located in areas of higher relief. Further south, even allowing for the effects of latitude, the lower relief leads to fewer orographic rainfall responses and hence fewer large settlements can be sustained. The basins in the central region are characterised by a series of alluvial fans which tend to attract settlements, whilst the saline soils and water towards the centre of the plains makes any large scale habitation difficult. Not surprisingly, the highland areas are the sources of several streams and rivers and these valleys attract settlements, both in the highland source areas and also further downstream in lowland areas. The direct effects of such a water supply are supplemented with groundwater consequences, which are discussed later. Beyond this generalised statement, villages in upland areas within any one region tend to be relatively more scattered than those in lowland areas.

ii) Water Supply - Water supply influences on settlement location reflect some of the points mentioned above, but need to be discussed at a much more detailed scale of resolution, especially with respect to wells, springs and qanats. However, discussion begins with reference to surface water supplies. Surface water is more abundantly available in the north, which is, of course, direct response to the higher relief and its effects on orographic rainfall. The principal rivers, such as the Atrak and the Kashaf-Rud are located in the north of Khorasan and these account for the locations of many settlements. The absence of any large river in the south does, in part, account for the lack of any major sizeable settlements in this region. The groundwater sources account for the water supplies to many settlements, either solely or in association with other surface water sources. Groundwater sources have proven to be a far more variable source of supply than surface water. In some cases fossilised reservoirs of Quaternary origin are being utilised, whilst in other cases the utilisation of water is outpacing the natural supply. The management of the supplies is worthy of additional discussion here as there are few cases of regional scale or basin scale agreements for water utilisation. Hence, some villages consume water at the expense of other (downstream) ones. In the north the groundwater resources are mainly restricted to the Mashhad region and this partly accounts for the vast concentration of settlements in this area. In general, the central areas of Khorasan are more dependent upon groundwater than those of the north, and therefore settlements tend to be more influenced by the location of reservoirs than surface rivers. This provides an interesting contrast with the north, especially when it is borne in mind that the groundwater sources are spread more widely throughout the central area and hence, although settlements tend to be clustered, the clusters themselves can be quite widely scattered. In the south there is a shortage of both surface and groundwater sources and hence settlements tend to be widely scattered to utilise the few limited sources which do exist.

iii) Soils - Fertility and salinity are the two most important pedological factors which influence the location and size of settlements. In general, the negative influence is more important, especially where saline soils restrict the opportunities for local agricultural production and hence lead to diminished economic potentials. In regional terms, salinity increases towards the south, which is partly a reflection of aridity and the absence of surface waters to flush salts within the soils. Salinity therefore is another important factor which influences the patterns of the south, in particular. Salinity does, however, also affect the soils of the central region, especially in the basins. Most of the rivers fail to penetrate beyond the alluvial fans and hence the soils of the central parts of the basins tend to be more saline; this salinity also affects the water supplies. This reinforces the tendency for settlements to be located at the peripheries of such basins.

Land use determinants: Chapters 7 and 8 discussed aspects of land reform and agricultural land use. Chapter 8, in particular, showed the significance of variations in topography, climate, water supply and soils on different types of agriculture; in turn the variations of economic potential, further exacerbated by distance from the principal markets, have accounted for people's decisions to stay, leave or migrate to various regions. It has been show, for example, that sugar beet production in some parts of the north is associated with a relatively affluent economy and hence fewer people tend to leave the region and so settlements remain or even enlarge. In the south, there are fewer opportunities for major developments in cash agriculture. Together with restricted employment opportunities, this accounts for the decline in the settlements in the region, displayed, in part, by the abandonment of many villages (see later). In the south, physical constraints further influence settlement locations and size through the medium of a limited potential of the local economy. There is no major cash crop production in the south, and most agriculture is in the form of livestock rearing. This contrasts with greater opportunities in the central and northern regions, although, once again, the physical constraints are the root of the true economic potential. A further point to be considered is the regional isolation of parts of the south, and even parts of the basins in the central region. This significantly limits the opportunities for the production of perishable goods, some of which may be apparently suited (such as melons). The absence of an adequate road system further emphasises this situation.

Population determinants: Population movements have proved the viability or otherwise for the continued existence of some of the smaller settlements. Chapter 9 has shown the impact of population growth and migration in some considerable detail. Population movements are, by and large, a response to living conditions and economic advantages in both the source and destination regions and so are linked closely to the points mentioned in the previous sections. Not surprisingly, through advantages of climate, topography, hydrology and pedology, the northern area has the most profitable rural production and hence rural population losses are relatively small. This contrasts with the very restricted opportunities in parts of the central region and, more especially, the southern region where economic opportunities are negligible and hence outward population movements from rural areas are common. This adds a regional dimension because, unlike the northern and central regions, there are no prosperous urban areas in the south to absorb the rural migrants and hence most of them move to other regions of Khorasan. This is another factor which has led to the abandonment of many villages. This particular phenomenon will now be examined more fully as a manifestation of the dynamics of settlement in the various regions of Khorasan.

ABANDONMENT OF VILLAGES

According to the 1976 census, 8040 villages had been abandoned in Khorasan since records began; of these 823 had been abandoned during the 1966 to 1976 decade. The simplistic interpretation of population decline, however, is not accurate (many of the abandoned villages had a population of less than 20 people) and disguises many of the underlying reasons and dynamics for the change. Population has continued to increase during this time, but the rural population has declined as a proportion. Reasons for abandonment include the scattered and small nature of the villages, political instability and insecurity, famines and epidemics, the expansion of urbanisation, modernisation, and general underlying migration tendencies. Above all others, however, the principal cause of abandonment has been the changing nature of the water supply. This issue will be examined more specifically after a brief description of the spatial dimensions of village abandonment and a more detailed analysis relating change to the surrounding topographic environment.

Pattern and distribution of abandoned settlements: Figures 10.1, 10.2 and 10.3 display the distribution of abandoned villages in each of the three areas of north, centre and south. When compared to the topographic and rainfall maps in Chapter 3, and hydrological maps in Chapters 4 and 5, it can been seen that there appears to be a good relationship. Although no specific statistical test was used to test this relationship, mainly because it was felt that such formality was inappropriate when using unspecific data, especially topographical, a strong visual relationship can be seen. A good example of this can be seen in the north (and more especially the north western parts) of

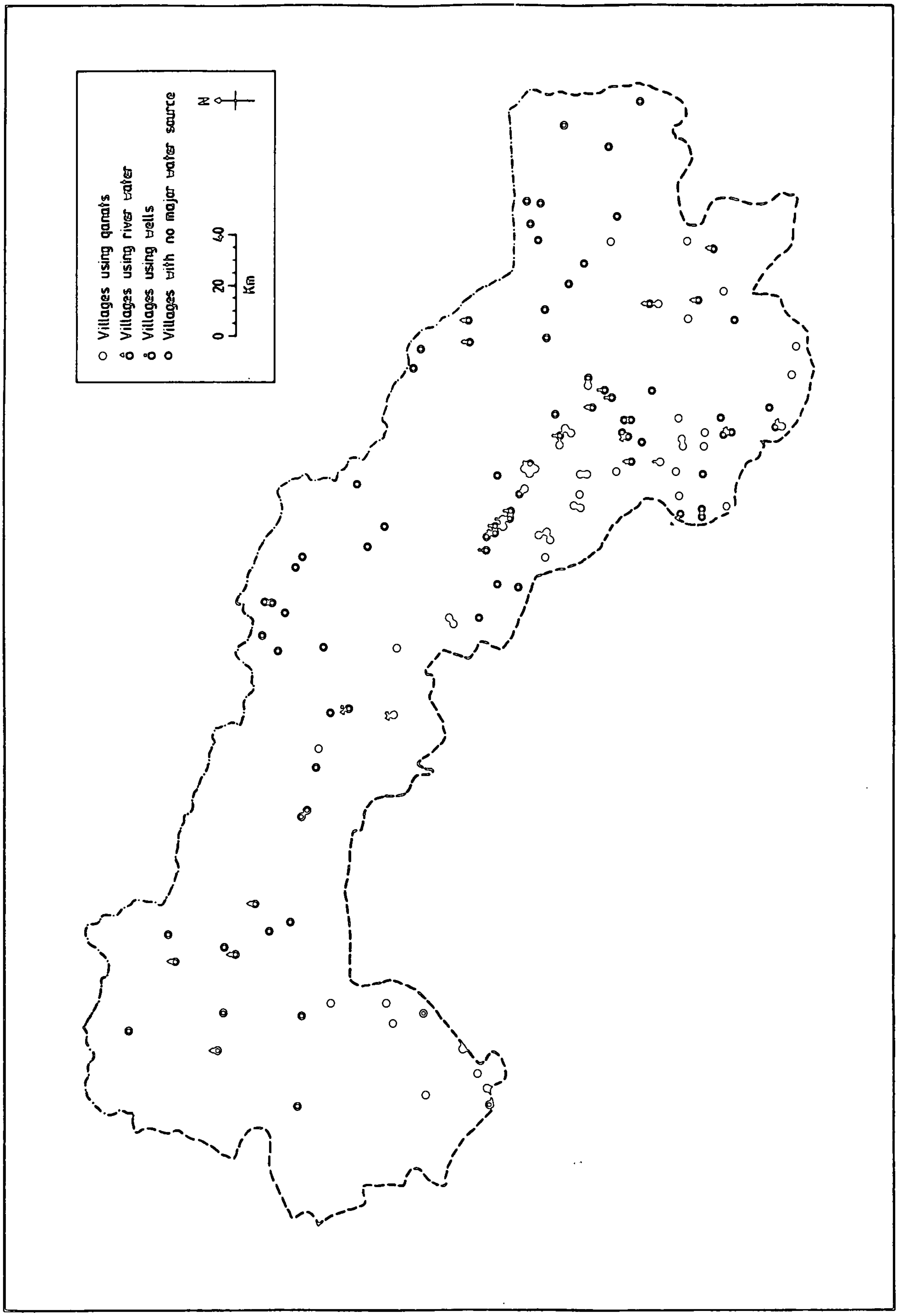


Figure 10.1 Abandoned villages in north Khorasan.

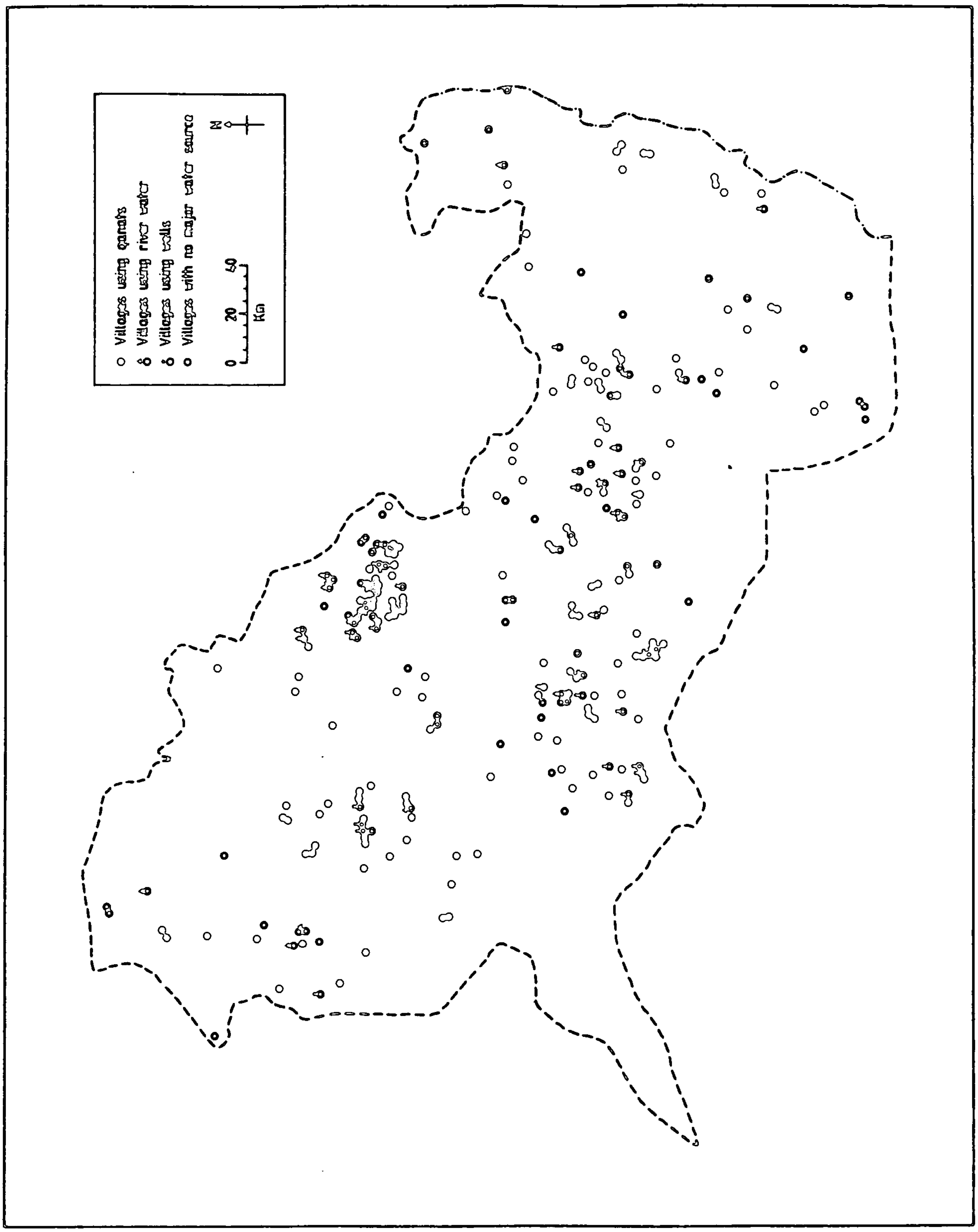


Figure 10.2 Abandoned villages in central Khorasan.

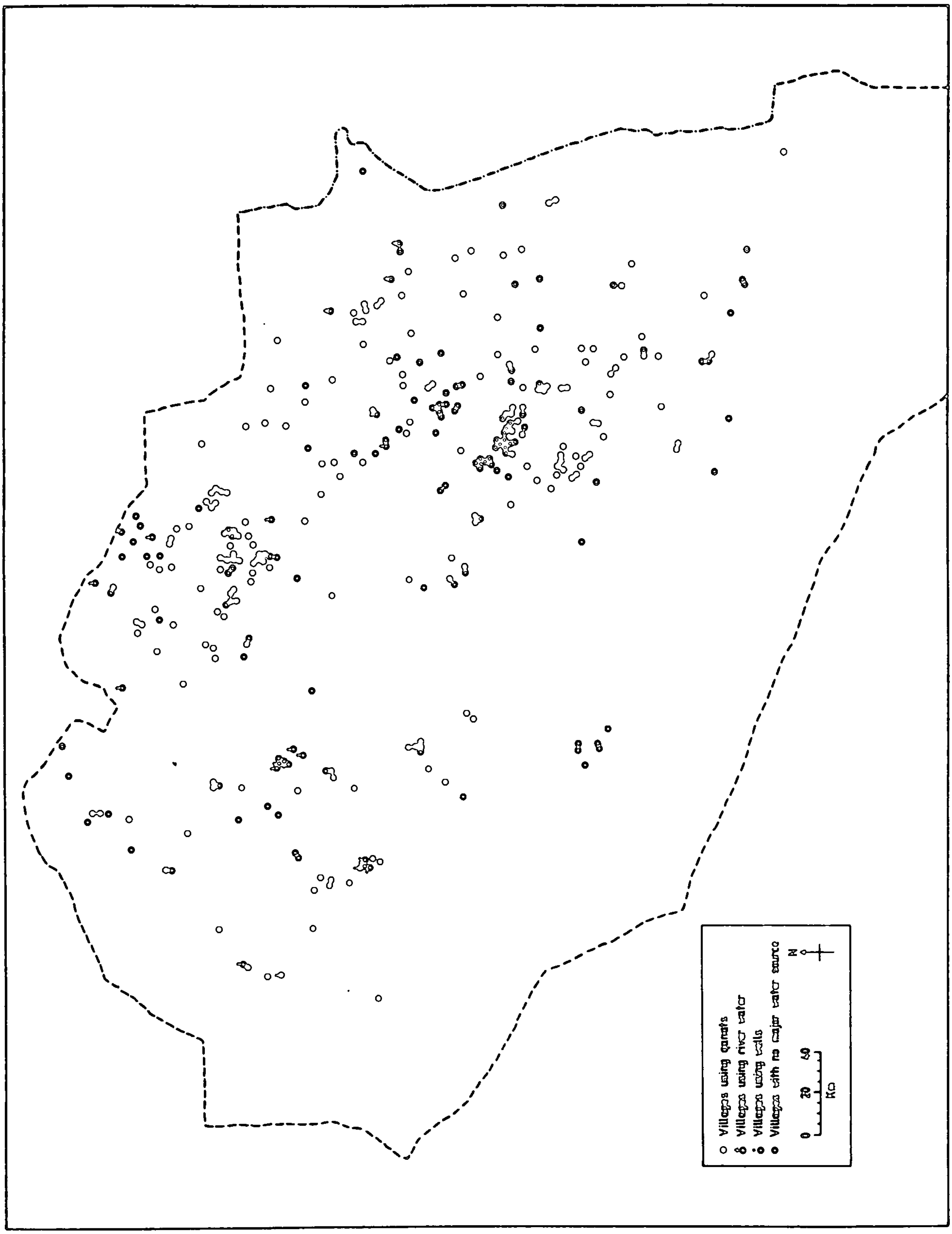


Figure 10.3 Abandoned villages in south Khorasan.

Khorasan, where the higher relief and associated rainfall has resulted in far fewer villages being abandoned. Further south, as the altitude decreases and also as the precipitation is less and more erratic the number of abandoned villages is greater. A large number of abandoned villages exists in the extreme south where the problems just highlighted are exacerbated by the unreliable and meagre groundwater supply. Even ignoring problems of water supply, the environmental conditions dictate that rural villages tend to be small, scattered and rather marginal in terms of their viability.

Of the 823 villages which had been abandoned between 1966 and 1976, 424 (or about half) had been located in upland areas. However, most of these are located in the Southern uplands, which are at a lower altitude to most of the upland areas in the north and centre, and which have a less reliable supply of surface and underground water. Most of these 'southern-upland' abandoned villages were also very small in 1966 with almost no potential for economic development or growth. A slightly different trend appears, however, when lowland abandoned villages are examined. Most of them are concentrated in the central area, particularly in the shahrestans of Neyshabur and Torbat-e-Heydariyeh. The principal explanation for this distribution can be linked to problems of groundwater utilisation, especially the use of qanats, and this is now discussed more fully.

Abandoned villages and water supply: If reference is made to Chapter 5, it can be seen that a great majority of the abandoned villages are those which had water supplied from qanats in 1966. Further reference to Chapter 6 reminds us that most of these settlements tend to be clustered, especially in the basins of central Khorasan, and around

Gonabad and Birjand in the south. Most villages have been abandoned subsequent to the drying up and abandonment of qanats which has been caused by:

i) Lowering of the water table - In some areas this has been the principal reason. This was especially so around Mashhad because of the increasing extraction which was necessary to cope with the growing population (Chapter 9). In some parts of the area the water table fell by as much as 11 metres and many qanats have subsequently dried up. Elsewhere in Khorasan, especially in the central area, the construction of deep wells (for example around Neyshabur) has also led to increased water extraction and a consequent lowering of the water table.

ii) Lack of maintenance and repair - Qanats are very vulnerable to hazards such as flooding, earth tremors, and shifting sands. When these are added to continual problems of general 'wear and tear' it can be seen that maintenance is a crucial aspect of the success of water supply by qanats. Unfortunately, maintenance is not always of the required standard and once population begins to decline through out-migration, causing problems of labour supply, the reliability of the water supply begins to be compromised. this can lead to less efficient agriculture and a declining economy, providing further stimulus for the out-migration of labour.

iii) Land Reform - Land reform (Chapter 7) caused a number of disputes over the ownership of both land and water supply. This led to delays in the repairing of qanats, rendering some of them beyond repair.

Abandoned villages in the central region have also been caused by problems of water supply from wells. This has been particularly marked around Neyshabur, Torbat-e-Heydariyeh, Torbat-e-Jam and Kashmar (and also in a few areas of the north around Mashhad). In many cases the wells have begun to dry up as a result of over-extraction.

In general, there are few abandoned villages associated with surface water supplies. Where they do exist, they are almost exclusively in the south. However, as these villages are not supplied by qanats, they are more scattered and so there is less clustering of abandoned villages here.

Generalisations: It can be said that villages both in upland and lowland areas are more vulnerable to abandonment in the south, as the area is more arid and the villages tend to be comparatively much smaller and more widely dispersed. However, due to there being fewer lowland villages in the south in absolute terms, the most dramatic area of abandonment has been the lowest parts of the basins in the central region. This has been exacerbated by the development of wells and qanats which has tended to make the abandoned villages fall into a series of clusters. In many cases, these villages in the central and northern regions have been abandoned due to water failures consequent to a lowering of the water table. Such circumstances are often caused by overextraction as a result of the rapidly increasing population (especially when compared to the southern areas) and so greater dependence is made on surface water supplies. In this respect it is fortunate that the central and northern regions receive a greater and reliable supply due to the topographical and precipitational characteristics of the area generally.

SETTLEMENT PATTERNS AND THEORIES

Introduction: This thesis began with some consideration of settlement theories, especially with those which concerned the arrangement of settlements in geographical space. In particular, mention was given to ideas of Central Place Theory, settlement rankings, and the historical evolution of settlement locations and functions. Having described and interpreted the principal arrangements of settlements in Iran, it is now necessary to return to some of these initial ideas, mainly to see how far order and arrangement is appropriate in the context of Khorasan.

Geometric order: In general, a hierarchy of settlements can be identified. Clearly Mashhad is the principal settlement in the province, but a series of sub-centres are also evident. The most important are the towns of Bojnurd (north), Neyshabur, Sabzevar and Torbat-e-Heydariyeh (centre) and Tabas and Birjand (south). The question arises as to how important each of these centres are as points in a local geometric hierarchy. Each of the above named, plus other settlements slightly lower in the hierarchy (such as Gonabad, Quchan and Ferdows), perform important nodal functions, such as the provision of services, including both trading and communications functions. However, it is possible to move away from such generalised, superficial and subjective interpretations by referring to a major report, "The Development Plan of Khorasan", which was published in 1972.

This plan was aimed at dividing the whole of Khorasan into settlement units, each with a clear and legally defined hierarchy. This is demonstrated in Figure 10.4. The plan proposed the establishment of units based on the influence of topographic features; this is clearly seen by noting the influence of principal centres at the node of many linear settlement routes, each of which is associated with principal river valleys (i.e. with favourable supplies of water and with the best communications). This is most clearly seen at Mashhad, Bojnurd, Neyshabur and Torbat-e-Heydariyeh. The hierarchy itself can be seen even more clearly with reference to Figure 10.5 which tries to define areas of settlement influence. In the plan Khorasan is divided up into four primary levels. The first order to Mashhad, the province capital. The next order is influenced by Bojnurd, Sabzevar and Birjand. The third order introduces the settlements of Quchan, Neyshabur, Torbat-e-Heydariyeh. The final 'primary' (that is to say urban rather than rural) level includes Shirvan, Dargaz, Esfarayen, Torbat-e-Jam, Kashmar, Gonabad, Ferdows and Tabas. More minor hierarchical levels can be seen from the figure.

The plan was never implemented, being overtaken by the Islamic Revolution of 1979, but it did clearly define order of settlement hierarchies and demonstrated the possibility of some geometric progression in a similar sense to the more traditional models. Of particular note, was that Khorasan was seen to be potentially at variance from the more 'traditional' Iranian interpretation of settlement order which was described in Chapter 1. Despite the presence of strong topographic features, including deserts, the plan was able to utilise these features to define nodes, as mentioned above - where water supply is unreliable, it is still possible to identify specific sites for development, even in the south. However, the fact that Figure 10.5 has a majority of centres in the first three orders in the north and centre is some testimony to the fact that water supply provides some limitation. There is also the separation of influence in the south from the centre and north by the physical barrier of the deserts linked to the Dasht-e-Kavir. Another aspect identified in Chapter 1 was the distribution of population, but this too is less of a problem due to the reorganisation which has taken place through migration (Chapter 9). The plan did not think it unreasonable to assume that people were more than ever likely to want to live in larger settlements, and this has been demonstrated in Chapter 9. The one dimension of English's (1966) thesis which has not been <u>clearly</u> resolved has been the cultural influence. There is reason to suggest that people are willing to recognise the influence of local, regional and provincial markets (and hence support notions of hierarchy) but there has, as yet, been no demonstrative proof of this.

Nevertheless, in conclusion, it can be shown that between 1966 and 1976 the settlement patterns of Khorasan have moved towards a 'potential' arrangement of geometric order and that the principal factors behind this have been those of changing water supply, land reform, economic potential and significant shifts in population location, all of which have been described in this thesis.

Appendix 2.1 Administrative divisions in Khorasan (1976)

Shahr-estan	Bakhsh	Village districts (Dehestans)
NORTHERN DIVISION		
Mashhad	Ahmadābād	Pivchzhan, Pain Valāyat, Sarjam.
	Chenārān	Bizaki, Chenārān, Chulāi, Darzāb, Rādkān.
	Humeh	Tabādkān, Miyān valāyat.
	Sarakhs	Sarakhs, Qal'eh Qassab, Kandakli, Mozdurān.
	Torqabeh	Ardemeh, Shāndīz, Torqabeh, Golmakān.
	Fariman	Fariman
	Kalat	Pasādkuh, Zāvin, Kabud Gonbad, Lāin Now.
Quchān	Bājgirān	Owghāz, Picharānlu, Jirestān, Qushkhāneh.
	Humeh	Ja'Farābād-e-Olyā, Ja'Farābād-e-Soflā, Chari, Kharq, Doghāi, Dowlat Khāneh, Shahr-e-Kohneh, Shirghān, Faruj, Kohneh Forus, Māyvān, Mezerj.
Shirvān	Humeh	Takmarān, Humeh, Devin, Zavārom, Ziyārat, Qoljoq, Sheykh, Amirānlu, Golyān.
Bojnurd	Jājarm	Jājarm, Sankhāst, Shoqān, Miyān Kuh Sārat.
	Jargalān	Jargalān, Hesārcheh, Gifān, Nokhudli.
	Humeh	Chenārān, Humeh, Kasebāyer, Garmkhān.
	Māneh-Samalqān	Maneh, Samalqān.
Dargaz	Chāpeshlu	Qarah Bāshlu, Miyānkuh
	Humeh	Seydābād, Gol Khanadān.
	Lotfābād	Qal'eh Hātam, Loftābād.
	Now Khandān	Takāb, Dorungar, Kalāteh Chenār, Now Khandān.
CENTRAL DIVISION		
Neyshābur	Taht Jolgeh	Taht Jolgeh, Tāghankuh, Eshqābād.
	Humeh	Darb Qāzi, Rivand, Māzul.
	Zabar Khān	Ardughesh, Eshaqābād, Zabar Khān.
	Sarvalāyat	Arbaqāyen, Bārma'dan, Sarvalāyat, Marusk.

Sabzevar	Joghatāy	Bālā Jovin, Pāin Jovin, Birākuh, Joghatāy, Hokmābād, Miyān Jovin.
	Humeh	Soltānābād, Qassabeh-e-Shomāli, Qassabeh-e-Jonubi, Qassabeh-e-Sharqi, Qassabeh-e-Gharbi, Karrāb, Tabas.
	Dāvar Zan	Bāshim, Kāh, Mazinān.
	Sheshtamad	Takāb, Khavāshad, Rob-e-Shāmāt, Zemej, Shāmkān, Forughan, Kuh Homāi.
Esfar-ayen	Bam va Safiabad	Bam, Safiabad.
	Humeh	Humeh, Ruin, Rezqābād, Fartān, Milānow.
Bāk-hezr	Humeh	Bālā valāyat, Pāin valāyat, Miyān valāyat.
Torbat-e-jam	Jannatābād	Jannatābād, Salehābād, Qal'eh Hammām.
	Humeh	Bālā jām, Pāin jām, Miyān jām.
Torbat-e-Heydariyeh	Humeh	Bālā valāyat, Bāyk, Pāin valāyat, Zāveh.
	Khāf	Bālā Khāf, Jolgehzuzan, Pāin Khāf, Miyān Khāf.
	Rosht Khār	Rosht Khar, Sangān.
	Feyzābād	Azghand, Mahvelāt.
	Kadkan	Bālā Rokh, Pāin Rokh, Rokh, Kadkan, Miyān Rokh.
Kāshmar	Bardeskan	Kenār Shahr, Kuh Pāyeh.
	Humeh	Bālā valayat
	Khalilābād	Barkāl, Rastāq, Sheshtarāz
	Kuh Sorkh	Barkuh, Takāb
	SOUTHERN DIVISION	
Gonābād	Bajestān	Bajestan, Jazin, Yunesi.
	Humeh	Bidokht, Humeh, Dului, Zibad, Kākhk.
Birjand	Humeh	Alqur, Shahābād,
	Khusf	Qeysābād, Barākuh, Khusf
	Darmiyān	Ma'rufān, Mo'men Ābād, Shākhenāt, Tabasmasinā Darmiyān, Doroh, Naharjān
	Nehbandān	Nehbandān, Basirān, Barg, Chāhān, Shusf, Mighān, Arabkhāneh, Neh.
	Qāenāt	Gorang, Gozokht, Shāhrakht, Zohān, Fandokht, Paskuh, Nim Boluk.

Ferdows	Boshruiyeh	Eresk, Asfāk, Boshruiyeh, Roqeh, Tarjad, Ghaniābād, Fathābād, Korond, Nignān, Hanviyeh.
	Humeh	Borun, Humeh, Khānehkuk, Mahvid.
	Sarāyān	Āyesk, Sarāyān, Sehqal'eh, Mosa'bi.
Tābas	Humeh	Esfahak, Jowkhāh, Halvān, Humeh, Deyhuk, Koreyt.
	Dastgerdān	Dastgerdān, Dehmohammad, Kuhyakhāb.

Source : 1. National Census of Population and Housing, November 1976, Khorasan Ostan.

2. Statistical Yearbook, 1980, Khorasan Ostan.

Appendix 2.2 Complete list of abandoned settlements (1966–1976) (derived from Village Gazetteers).

KEY

Road condition	A	Rail roads
	B	Paved roads (Asfalteh)
	C	Gravel roads
	D	Dirt track
	E	Road passable by jeeps
	F	Road passable by draft animals
Topography	U	Upland
	L	Lowland
Source of water supply	Q	Qanat source
	R	River source
	S	Spring source
	W	Well source
	DW	Deep well source

Villages abandoned during 1966-1976	Type of Road in 1966	Topography	Source of water supply in 1966	Absolute population in 1966
NORTHERN DIVISION				
Chādor Askar	E	U	Q	2
Sarzāb-e-olyā	E	U	R	8
Hasan Adu	E	L	-	10
Shāh Bandeh	F	L	Q	22
Aminābād	D	L	-	11
Istgāh-e-Kāshmar	A	L	-	22
Cheshmen-ye-Muhammad Mirzā	C	U	S	20
Hāyiābad	E	L	Q	19
Fāzel	E	U	R	11
Kalāteh-ye-Shur	D	L	-	11
Gololar	E	L	Q	22
Mehdiābād	E	L	Q	24
Jalālābād	D	L	W	98
Juy Now	F	L	R	28
Chahārtā Gāv	D	U	R	72
Hasanābād	D	L	DW	146
Hayiābād	D	L	S	28
Rahimābād	E	U	R	21
Siyah-e-Bālā	E	L	R	19
Azimābād	D	U	R	25
Qarneh-ye-olyā	D	U	Q	32
Kārghsh-e-Soflā	D	U	S	58
Gaziband	D	L	Q	16
Goleh Cheshmeh	D	U	Q-S	33
Barkol	D	U	R-W	95
Chahār Bāgh	E	L	W	2
Chahār Bāgh-e-Asiyāb	E	L	-	3
Kheyteh-ye-Qāeni	E	L	R	25
Deh Now-ye-Kenār Gusheh	D	L	Q-DW	212
Ali Kuri	E	U	_	20
Kalāgh Āhan	E	L	R	10
Namdān	E	L	Q-W	27
Yār Dasht	D	L	DW	12

Āqsahrā	E	L	DW	57
Ashkoran	D	L	Q	42
Hoseynābād-e-Nāsi	E	L	DW	19
Kheyrābād	D	L	DW	442
Dāsh Bolāgh	F	U	S	170
Sabuseh	E	U	DW	70
Sharifābad	D	L	W	44
Shurak	D	U	Q	1
Kalāteh-ye-Dargāh	F	U	S	116
Musāābād	E	L	-	23
Bijark	F	L	-	12
Saluti	D	U	-	16
Azizābād	E	L	-	-
Aq Malek	E	L	-	-
Piyāzi	D	U	R	54
Cheshmeh Mirali	E	U	Q	49
Dotalkhi	E	U	Q	3
Deh Mollā	D	L	Q	11
Kolāh Bakhsh	E	L	Q	67
Golamābād	D	L	Q	7
Ma'dan	D	U	-	10
Shāhideh	D	L	Q	6
Qorqi	D	U	Q	7
Kalāteh-ye-Abfol	E	U	Q	9
Bildar	D	L	Q	63
Dāghestān	E	U	Q	7
Bueh Gaz	E	U	-	29
Bongesh	E	U	Q.S.R.	47
Cheshmeh Heydar	F	L	Q	6
Cheshmeh Gandeh	D	U	-	64
Derakht Bid	E	L	S	116
Tabaqsar	D	U	S	3
Qasr	D	L	Q	44
Kamar Zard-e-Soflā	D	U	S	21
Jahand-e-Bālā	E	L	-	34
Chāh Kalleh	E	U	-	43
Cheshmeh-ye-Haji Abbās	F	U	-	37
Chehel Kamān	E	U	R	65

Khāngiran	E	U	-	35
Bandarābād	E	U	Q	8
Talkhābād	F	U	Q	15
Abbāsābād	E	U	Q	17
Chāh-e-Sarvar	F	L	-	20
Cheshmeh Qabrestān	F	U	S	19
Kārizak	D	L	Q	157
Kalāteh-ye-Mehdiābād	E	U	Q	70
Kalāteh-ye-Ahmad	F	U	Q	11
Mazraeh-ye-Ayaiyrh	C	U	S	28
Akbarābād-e-Shāhzādeh	D	L	Q	52
Beshnow	D	L	W	41
Sayyedābād-e-Kamingarān	D	L	W	13
Qezel Hesār	D	L	Q	31
Motor-e-Āb-e-Hasanābād	D	L	W	31
Chahār Qāldi	D	U	Q.S.R.	2
Zākerānlu	F	U	S	2
Hasār Kharābeh	E	L	-	4
Qāsemābād	E	L	S.R.W.	24
Malekābād	E	L	Q.R.DW	106
Naqāreh Khāneh	E	L	Q	30
Chehel Bāzeh	F	U	-	65
Doqquzābād	D	L	Q	25
Soltānābād	D	L	Q	-
Incheh Kohneh	C	U	-	39
Fathābād	C	L	Q.S.W.	320
Emām Abdollāh	D	U	-	5
Nosratābād	D	U	Q	30
Sharik-e-Bāghān	E	L	Q	18
Zamān	D	L	Q	5
Kazdar	D	L	Q	25
Bābānestān	E	U	-	8
Ali Bolāgh	F	U	-	2
Kalāteh-ye-Ebrāhim	E	L	R	11
Kalāteh-ye-Sufihā	D	L	R	7
Kalāteh-ye-Maqsudi	F	U	R	4
Kalāteh-ye-Sheykh Ali	D	L	S	15
Bāqerābād	A	L	Q	22

Hoseynābād	D	L	Q	61
Doborjeh	A	L	Q	44
Ganjeh Gah	E	L	Q	2
Nim Istgāh	A	L	_	7
Cheshmeh-ye-Sayyed	D	U	-	9
Rajabali-e-Dāshāb	F	U	-	9
Chanār Darreh	F	U	-	25
Suleh Qavāq	F	U	S	9
Ja'farābād	E	L	Q	14
Hamzeh Chāh	F	L	-	66
Qāsemābād	F	L	Q	6
Kalāteh-ye-Mir Hāshem	F	L	Q	15
Zāvdār	E	U	S	5
Mahmudābād	E	L	R	5
Kharābeh	F	U	R	28
Shar Darreh-ye-Shamāli	E	L	R	17
Qush Dirmān	F	U	R	24
Allāh Dād	D	L	R	5
CENTRAL DIVISION				
Sariyan	D	L	R	176
Borj	D	L	Q	259
Sefid-e-Bālā	D	L	Q	4
Garmeh	D	U	W	139
Sar Gholonbeh	E	L	Q	31
Shamsābād	-	U	-	49
Sabr Bibi	D	U	S	14
Ardār Sang	E	U	Q	3
Kamand	D	U	Q	12
Garmāb	E	U	-	1
Kalāteh-ye-Mirzā Hasan	D	U	Q	15
Kalateh-ye-Rowhāni	D	L	Q	7
Nivāl	C	U	Q	8
Now Deh	D	L	Q	11
Hoseynābād	D	U	Q	24
Rezqābād	D	U	DW	16
Aliābād	D	L	Q	12
Karimābād	D	L	Q-R	1
Kashaf Rud	E	L	Q	2

Sayyed Ali	E	U	Q	9
Chāh Shur	F	L	Q	13
Shir Ahmad	F	L	Q	3
Tayyebi	E	L	Q	7
Aliābād	E	L	Q	1
Qal'eh Now	E	L	W	5
Kalāteh-ye-Āhangarhā	D	L	Q	9
Gowd Āqel	E	L	Q	63
Mohsenābād	E	L	W	1
Esmāilābād	F	L	Q	3
Akbarābād	F	L	Q	17
Sa'dābād	F	L	Q	18
Sayyedābād	D	L	W	9
Ghol Gardan	E	U	Q	20
Āhvān	F	U	R	4
Hantehābād	D	L	Q	20
Shāhābād	F	U	Q	6
Kalāteh-ye-Gol	E	L	-	4
Kalāteh-ye-Ramazān Ali	F	U	R	12
Kalāteh-ye-Hāji Abdol Hoseyn	D	U	Q	11
Kalāteh-ye-Ma'sum	D	U	Q	4
Kalateh-ye-Haji Soltan	D	U	Q	11
Hamireh	E	U	Q	38
Yusefi-ye-Soflā	F	U	Q	16
Chāh-e-Amiq-e-Ahmad	D	L	DW	5
Kamuj	D	U	Q	9
Hemmatābād	D	L	Q	2
Ebrāhimābād	D	L	W	6
Bāghak-e-Soflā	E	U	Q	101
Firuz Kuh	E	L	Q	394
Nāmeshgarān	D	U	Q	2
Hoseynābād-e-Malek	B	L	Q	222
Rasulābād	F	L	Q	21
Shurāb-e-Olyā	D	L	Q	104
Ali Yāghi	D	L	Q	17
Kāriz Gondeh	D	L	Q	15
Qat'eh Hammam	D	L	Q	133

Kāriz Now	D	L	Q	51
Mallow-ye-Soflā	D	U	S	18
Hezāreh	D	L	Q	50
Shir Palang	F	L	Q	12
Qongor	E	L	R	33
Borj-e-Qelich Khān	E	U	Q-R	26
Kalāteh Barfi	F	L	S	44
Sirzār	F	U	Q	80
Hāyiābād	E	L	Q	41
Ahmadābād	D	L	Q	204
Barghanābād	F	U	Q	2
Robat Ziyārat	E	U	S	28
Shir Khan	D	L	Q	17
Fakhrābād	D	L	-	10
Manqāb	E	L	Q	118
Esmāilābād	D	L	W	92
Bahārmashk	F	L	Q	22
Cheshmeh Rowghani	F	U	S	9
Ābjar-e-Soflā	F	U	Q	47
Ābjar-e-Olyā	F	U	Q	107
Arvi	F	U	-	34
Dāsh Khāneh	D	L	Q	47
Boqsāni	D	L	Q	88
Teymur-e-Soflā	E	U	Q	26
Aliābād	E	L	Q	50
Kalāteh-ye-Khuni	E	U	Q	104
Mast Ali	E	L	W	4
Mohammadābād-e-Mostowfi	E	L	Q	236
Cheshmeh Zard	E	L	Q	1
Rāf	E	L	W	66
Sayyedābād	E	L	W	34
Kāzemābād	E	L	Q	81
Gāv Gerd	E	U	S	4
Chāh-e-Atā	E	L	-	53
Chāh-e-Gaz	D	U	-	75
Chāh-e-Matār	E	L	Q	101
Deh Borzu	F	U	Q	24

Shaklu-ye-Soflā	F	U	-	52
Shaklu-ye-Olyā	F	U	-	26
Kāl jangi	E	U	Q	51
Gilāb	E	U	Q	25
Mahābād	E	L	Q	75
Khāniq	D	L	Q	26
Kalāt-e-Mondha	F	U	Q	8
Golestān	D	L	Q	17
Nurābād	D	L	W	1
Arghnān	D	L	Q	76
Izadiyeh	E	U	Q	39
Afzalābād	E	U	Q	13
Akbarābād	D	U	W	11
Baqi	D	U	S	160
Bisheh Sāq	F	U	R	22
Bāz Gir	C	U	Q	123
pā Godār	D	U	Q-R	249
Jalālābād	D	L	Q	13
Ja'farābād	D	L	R	17
Rowshanābād	F	L	-	45
Shastān	D	U	Q	216
Shurāb	E	L	S	111
Shād Kan	E	U	Q	15
Qolābād	E	U	Q-R	69
Qal'eh Now-ye-Askar Zāi	D	L	Q	82
Kalāteh-ye-Now	D	U	Q	54
Mohammadābād-e-Hazrati	D	L	W	28
Mohammadābād	D	L	Q	88
Nasirābād	D	U	Q	369
Ney Sabz	D	L	Q	51
Aminābād	D	L	Q	61
Pey Godār	E	U	Q	82
Joghrāti	E	L	Q-R	8
Sar Chehel-e-Olyā	E	U	R	131
Tāherābād	F	L	-	20
Kolāh Derāz	F	L	-	41

Mirzāi	C	L	R	2
Mohammad Chāq	C	L	Q	14
Neqāb	D	L	Q	20
Borāq	E	U	S	27
Sar Gol	E	U	S	84
Shesh Āb	E	U	S	76
Qāderiyeh	D	L	Q	12
Poshtāb-e-Nezām	E	L	R	7
Chāh-e-Nimeh Amiq-e-Gholān Hasan	E	L	-	2
Chāh-e-Tāher	E	L	-	2
Chāh Khormā	F	L	Q	28
Khorramābād	F	L	Q	58
Deh Now	E	L	Q	17
Dāniyāl	E	L	Q	46
Rahmatābād	D	L	-	27
Salmi Dasht	E	L	Q	6
Shāh Rag	E	L	Q	2
Alui	D	L	Q	127
Qahrmāniyeh	E	L	Q	122
Moinābād	E	L	Q	9
Asadābād	E	U	Q	18
Habibābād	E	L	Q	145
Sar Rig	C	L	Q	49
Ziyā'ol Molk	D	L	Q	17
Māh Khosravi	E	L	S	6
Aminābād	F	L	R	5
Esmāil Baluch	F	U	Q	18
Hāj Manu	E	U	Q	5
Sadrābād	C	L	R	7
Arabshah Kalāteh	F	L	Q-R	5
Qal'eh-ye-Ātashgāh	F	L	Q	2
Kalāteh-ye-Mohammad Hoseyn	F	L	-	14
Kalateh-ye-Bahmani	D	L	S-R	1
Gāv Rangi	F	U	Q	2
Chāh Sabz	F	L	Q	6
Kalateh-ye-Hajreh	E	L	R	54
Sang Lālā	E	U	Q	16

Buzestan	F	U	S	28
Garmāb	F	L	R	5
Asgharābād	F	L	Q	5
Buzh Dāru	F	U	R	11
Pir Sorkh	E	L	Q	4
Hojatābād	E	U	Q	4
Hasanābād	F	L	Q	2
Kalāteh-ye-Sheykh Ali	F	U	Q	1
Amirābād	C	U	Q	6
Jahānābād	E	L	Q-W	23
Jannatābād	E	L	W	2
Soltānābād	D	L	Q	7
Azizābād	E	L	Q	117
Abdi	E	L	Q	27
Abbāsābād	D	L	R	5
Kalāteh-ye-Barq-e-Soflā	E	U	S	15
Kadughan	E	L	DW	14
Masihābād	E	L	Q-W	81
Ma'sumābād	F	L	Q	4
Jangal	-	U	-	7
Hajiābād	E	U	Q	25
Shojai	F	U	Q	5
Qabr Sefid	E	U	Q	32
Kalāteh-ye-Khān	F	U	-	7
Mobārak Shāh	E	U	Q	8
Shigān	E	U	Q	27
Avaz Verdi	E	L	Q	62
Kalāteh-ye-Hasan Ali	E	U	Q	48
Amirābād-e-Tabaq	E	L	Q	68
Hasār-e-Gowdāl	F	L	W-DW	85
Hoseynābād-e-Olang	E	L	W	83
Jannatābād	E	L	Q	41
Kheyrābad	D	L	-	116
Khalilābād	E	L	DW	30
Dastgerd	E	L	-	22
Aliābad	D	L	-	19
Fātemiyeh	E	L	R	13

Frrokh Jān	E	L	Q	28
Kalāteh-ye-Ebrāhimābād	D	L	Q	62
Kalāteh-ye-Now Bahār	E	L	Q	129
Kalāteh-ye-Vahdat	E	L	DW	10
Kushk	D	L	-	29
Kalāghi	E	L	W	20
Mohammadābād	E	L	Q	68
Voqufi	D	L	Q	19
Elāhi	E	L	W	41
Hājiābād	C	L	R.DW	62
Khomār	E	L	Q.R	97
Deglāni	C	L	Q.DW	24
Din Ali	C	L	Q	48
Delgand	E	L	W	42
Eynābād	C	L	W	58
Aliābād-e-Shur	C	L	W	21
Feyzābād	F	L	Q	16
Fulād Forush	D	L	Q	31
Nim Istgāh	D	L	-	43
Kāriz Now	E	U	Q	12
Khedershāh	E	U	S	50
Abdiyeh	F	L	Q	38
Alvan	D	L	-	10
Hoseynābād	E	L	Q	77
Abbāsābād	E	L	Q	21
Arab Kuseh	E	L	Q	32
Kazemābād	F	L	Q	16
Kanz Now	F	L	Q	104
Kalāteh-ye-Haj Mohammad	E	U	Q	53
Kalāteh-ye-Hasar-e-Mortazavi	D	L	Q	13
Bāgh-e-Hasan Qor	E	L	Q	8
Kalāteh-ye-Hāj Musavi	E	L	Q	8
Gorgi	E	L	Q	4
Gangābād	D	L	-	2
Mortezāābād	E	L	Q	14
Mehdiābād	E	L	Q	45
Hemmatābād	D	L	Q	66
Chang Boz	F	U	R	5

Dar Qal'eh	F	U	R	3
Sheykh Abolhasan	F	U	Q-R	13
Kamar Kandall	F	U	R	2
Gach Darreh	F	U	S	8
Gareh Cheh	E	U	Q-R-S	300
Qowlās	D	U	Q	17
Mangān	D	U	R	26
Bahārestān	E	L	Q	73
Ja'fari	D	L	Q	66
Dāsh Khāneh	E	L	-	20
Sāvoj	E	L	-	7
Kalāteh-ye-Abbasābād	F	L	Q	10
Milābād	D	L	Q	22
Kalāteh-ye-Haj Asaad	D	L	Q	6
Dareh Khār	F	U	S	19
Ankarān	F	U	S	5
Siyāh Khanēh	E	U	S	69
Hoseynābād	F	U	Q	42
Krezh Deh	E	L	R	36
SOUTHERN DIVISION				
Pish Kuh	F	U	Q.R	16
Taquk	F	L	Q	7
Hoseynābād	F	U	Q	4
Hoseynābād	D	U	Q	1
Khayrābād	F	U	-	2
Dasht Asu'	F	U	Q	10
Sangābād	F	U	Q	78
Shirdang	F	U	Q	11
Shir Kuk	E	U	Q	36
Kalāteh-ye-Sardār	F	U	Q	9
Kalāteh-ye Fatād	F	U	Q	11
Goleh Chashmeh	F	U	-	41
Nahangābād	E	U	Q	14
Ali Haji	F	U	Q	12
Kalāteh-ye-Abbās	F	U	Q	2
Mohammad Beyg	E	U	Q	2

Esmāilābād	D	L	-	16
Akbariyeh	D	L	DW	122
Chah-e-Zard	D	L	Q	81
Fakhrābad	D	L	W	36
Dey Godār	E	U	Q	5
Jarestān	F	U	Q	12
Chah-e-Shur	E	L	Q	9
Chāh-Kulak-e-Pāin	F	U	Q	18
Cheshmeh Khuri	E	U	S	18
Hālemi	F	U	Q	25
Sangāb	E	L	Q	6
Sabalgun	F	U	S	15
Saqoreh	F	U	Q	6
Shārqony	E	U	Q	22
Feyzābād	F	L	Q	13
Kalāteh-ye-Karbalāi Ali	E	U	R	2
Galu pam	F	U	S	12
Ebrahimābad	E	L	Q	21
Chestak-e-Bālā	E	L	Q	11
Ziruk	F	U	Q	31
Aliābād	F	U	Q	11
Cheshmeh Qasēm	E	U	Q	5
Kalateh-ye-Mosayyeb	E	U	Q-R	7
Now Deh-ye-Soflā	E	U	Q	8
Aghāz	E	U	Q	7
Bidar	F	U	Q	23
Hasanābād	E	U	Q	4
Khunik	F	U	Q	17
Kheyrābād	F	U	Q	5
Delābād	F	U	Q	5
Sarkhgān-e-Bālā	F	U	Q	10
Kalāteh-ye-Hoseynābād	E	U	R	18
Kalāteh-ye-Khosrow	F	U	Q	6
Kalāteh-ye-Zehāb	F	U	-	9
Husān	F	U	Q	32
Argini-ye-pāin	F	U	S	6
Eyvān Keyf	F	U	-	3
Asiyāb-e-Kom Sabz	E	U	-	7
Asiyāb-e-Ali Hoseyn	E	U	-	2
Asiyāb-e-Hāji	E	L	-	8

Asiyāb-e-Shur Fariz	E	U	-	6
Asiyāb-e-Gholām-e-Heyrani	F	U	-	4
Argini-ye-Bālā	F	U	S	8
Asiyāb-e-Gholam Hoseyn	E	U	-	7
Bil Dasteh	F	U	S	7
Bangābād	F	L	S	12
Tak Amārān	F	U	S	5
Takāvaki-ye-Olyā	F	U	S	29
Takavāki-ye-Soflā	F	U	S	42
Torkani	F	U	S	6
Torshāb-e-Bālā	F	U	Q	6
Tak Rān	F	L	S	7
Chashmeh-ye-Alī Qarbān	F	U	Q	5
Raqni	F	U	S	3
Sayyed Ali	F	U	Q	5
Shuqanju	F	U	Q	6
Shurāb	E	U	Q	6
Shams Ādi	F	U	S	18
Kalāteh-ye-Mollā Ali	E	U	Q	5
Kut Jaghāleh	F	U	-	10
Gazuk	E	U	S	5
Mochlageh	F	U	Q	14
Mollā	F	U	S	6
Now Bahār	E	U	Q	3
Nayeb Rajab	E	L	Q	8
Hursishk	F	U	Q	5
Hurik	F	U	Q	8
Hasanābād	F	U	Q	12
Hoseynābād	F	U	Q	22
Davudi	E	U	Q	7
Daraj	E	U	Q	177
Rumanjān	F	U	S	6
Aliābād	D	U	Q	39
Kalāteh-ye-Jamshidi	D	L	W	17
Kalāteh-ye-Musā	E	U	Q	12
Gorāz Kunik	F	U	Q	14
Neydān	F	U	S	9
Ebrāhimābād	E	L	Q	8
Hoseynābād	F	U	S	30

Sorkhang	E	U	S	13
Mohammadābād	E	L	Q	11
Akul	E	U	Q	3
Tighdar-e-Soflā	E	U	Q	14
Hasan Ne'matollah	E	U	Q	7
Dahan Rud	E	U	Q	32
Darigaz	E	U	W	3
Tāherābād	D	L	Q	3
Kalatēh-ye-Lotfollāh	F	U	Q	7
Kalatēh-ye-Shafi	E	U	Q	2
Hashtugān	D	U	Q	58
Āvaj	D	U	S	61
Bargu	F	U	Q	51
Cheshmeh Tuti	E	U	Q	3
Hajiābād	F	U	Q	3
Kheyrāt	C	U	S	6
Khātunābād	E	U	-	6
Dastjerd	E	L	_	13
Zangui	C	L	S	17
Sālehi	F	U	W	1
Eshqābād	F	U	Q	38
Abbāsābād	E	U	-	7
Kutbāl	E	U	Q	7
Kuchā	E	L	Q	2
Givrā	C	U	S	8
Nurābād	F	L	Q	8
Varāz	F	U	Q	6
Hemmatābād	E	L	Q	9
Ahmadābād	D	U	Q	9
Afzalābād	D	L	Q	69
Asfārāt-e-Vostā	D	U	Q	7
Bahārān	F	U	Q	18
Bahram	D	U	Q	6
Pudneh	E	U	Q	1
Chāh-e-Amyār	D	L	W	9
Hasanābād-e-Kāveh	D	L	Q	36
Raziābād	D	L	Q	31
Senjeduk	F	U	Q	4
Soleymānābād	E	U	Q	5
Samadābād	D	L	-	6
Taherābād	F	U	Q	12

Kateh Zar	F	U	-	5
Kasur Sukhteh	F	U	Q	5
Golvand	E	U	Q	98
Mahmudābād	F	L	Q	11
Bardud	F	U	R	97
Cheshmeh Mashref	F	L	-	2
Sar Tangal	F	U	S	8
Gerd Korgh	E	L	-	45
Torshāb	E	U	S	23
Chāduk	F	U	Q	16
Seh Kuheh	E	U	-	7
Boz Koshān	E	U	Q	11
Purchah	E	U	-	9
Chāh Heydar	E	U	-	8
Chāh Gazi	E	U	-	16
Kalāteh-ye-Mazār	E	U	S	58
Lākh Bābāi	F	U	-	5
Mohammad Rostam	F	U	-	15
Ja'farābād	F	U	-	1
Sar Gazan	F	U	-	20
Soltanābād	F	L	Q	16
Kalāteh-ye-Mazār	E	U	Q	10
Gazandar	F	U	Q	1
Tuleski	F	L	Q	4
Chanār	E	U	Q	3
Hojyatābād	D	U	DW	5
Senjetak	F	U	Q	6
Abbāsābād	F	U	Q	8
Anjireh	E	U	S	4
Sar Rig	E	L	W	14
Shah Kuhak		U	S	2
Karq Tāq	E	U	W	5
Māh Kuh	E	U	-	22
Āhangari	E	U	Q	12
Baqong	D	U	Q	14
Pastang Pāin	E	U	Q	8
Teymuri-e-Bālā	E	U	Q	11
Hājiābād	D	U	Q	8
Rokneddin	E	L	Q	24

Salujān	D	U	Q	15
Sarzeh	E	U	Q	97
Aliābad	D	L	Q	1
Abdolābād	D	U	Q	10
Kalatēh-ye-Khān	D	L	S	26
Kalāteh-ye-Mir	E	L	Q	3
Kalatēh-ye-Emāmi	D	U	Q	15
Golriz	F	U	Q	3
Mohammadābād-e-Shidar	D	L	Q	9
Nik	D	U	Q	22
Yekeh Derakht	C	U	Q	13
Chāh-e-Hasan-e-Eshqi	E	L	-	1
Hasanābād	E	L	Q	19
Hoseynābād	D	L	Q	105
Reykhāvand	F	L	Q	4
Rudgaz	C	L	Q	21
Zibad	F	U	Q	10
Fāzeli	E	L	W	12
Kalāteh-ye-Qeychi	D	L	Q	10
Kalāteh-ye-Karbalai Hasan	D	L	Q	8
Helāli	C	U	Q	22
Hāshemābād	E	U	Q	12
Chāh Āhani-ye-Vostā	F	U	Q	4
Rudgaz	E	U	Q	4
Zeynābād	D	L	Q	1
Soltaniyeh	D	L	Q	52
Sarāju-ye-Soflā	F	U	Q	9
Siyāh Darreh-ye-Olyā	D	U	Q	16
Siyāh Darreh-ye-Vostā	F	U	Q	2
Shur Chāh	E	U	Q	26
Arābād	F	U	Q	2
Aliābād	D	U	Q	6
Kalāteh-ye-Shir	D	U	Q	6
Mirābād	C	L	Q-R	2
Deh Shur	D	L	Q	6
Sayyed Morād	E	L	Q	10
Ahmadābād	D	L	W	2
Bargaz-e-Sofla	D	L	-	18

Barqiyu	D	L	Q	7
Chāh Shirin	D	L	-	2
Hoseynābād	D	L	-	9
Howz-e-Sorkh	E	L	-	3
Dizābād	D	L	Q	2
Robāt-e-Kamāi	C	L	-	6
Shamsābād	D	L	Q	9
Kalāteh-ye-Nikkhāh	D	L	Q	2
Kalāteh-ye-Qahremāni	D	L	Q	7
Mār Kuhak	D	L	-	3
Ma'dan-e-Khāk-e-Nasaz	D	U	-	6
Neyestān	D	L	-	3
Kom Chenār	E	U	Q	4
Tak Darghanj	F	U	Q	6
Chashmeh Sefid	E	U	Q	29
Hajrābād-e-Pāin	F	U	Q	7
Deh Now	D	L	Q	13
Siyāh Sang	F	U	Q	5
Sagnaj	F	U	Q	5
Kalāteh-ye-Mollā	F	U	Q	77
Kalāteh-ye-Āmer	F	U	Q-S	11
Kalāteh-ye-Ali Mortezā	F	U	Q	14
Golābād	F	U	Q	33
Maghāt	F	U	Q	3
Zabihābād	D	L	W	60
Asfāku	E	L	S	6
Eshqābād	E	U	Q	6
Kalāteh-ye-Now	E	L	Q	13
Durak	F	U	Q	8
Mazraeh-ye-Khāksār	E	L	W	8
Motor-e-Tavusi	D	L	W	2
Motor-e-Ādel	D	L	W	1
Motor-e-Moqimi	E	L	W	1
Allāhābād	D	L	-	1
Farkhondeh	E	L	Q	4
Kāl Zereshk	E	U	Q	6
Allāh Borji	E	U	Q	1

Olang	E	U	Q	7
Peyvāl Zard	F	U	Q	4
Habibābād	D	L	R	1
Shādaki	E	L	Q	1
Bishehgān	F	U	Q	9
Talkhi	F	U	Q	36
Khāvar-e-Bālā	F	U	Q	30
Dar Chenār	F	U	Q	6
Kalateh-ye-Karbalai Abbas	F	U	S	2
Gazbu	D	U	Q	12
Gazneshk	F	U	Q	23
Cheshmeh Khori	E	U	-	21
Sar Gilu	F	L	Q	17
Duk Bacheh	F	U	S	6
Lanjnunak	E	L	Q	4
Nakl-e-Olyā	F	U	R	4
Balāl Mazraeh	E	U	S	6
Beshād	D	U	Q	18
Aliābād	D	U	Q	5
Bad Gaz	F	U	Q	3
Hajiābād	D	U	Q	4
Khādemābād	E	U	Q	12
Khārtud	E	U	Q	82
Sardāb	F	U	S	3
Sahebābād	F	L	Q	6
Kalāteh-ye-Mollā	D	L	Q	3
Chāh Ali	F	L	W	7
Bisheh-ye-Olyā	F	U	Q	7
Hojjatābād	E	L	Q	6
Hesām	F	U	Q	8
Kheqrābād	D	L	W	11
Deh Now-ye-Boluriyan	D	L	W	14
Rud Ney	E	U	Q	9
Sar Juy-e-Bahārestān	E	L	Q	7
Feyzābād	E	L	Q	5
Beheshtābād	D	L	W	13
Saādatābād	D	L	W	6
Tolni	D	L	W	9
Qodratābād	D	L	Q-W	21
Naqiābād	D	L	Q	22
Tubu	F	U	S	3

Hājiābād	E	L	Q	9
Salv	D	U	Q	2
Samadiyeh	D	L	Q	7
Mohammadiyeh	E	L	Q	6
Motori	D	L	W	2
Shojāiyeh	D	L	Q	6
Abdolābād	E	L	Q	2
Fathābād	D	L	Q	9
Āb Boneh	F	U	S	9
Āb Reza	E	L	S	9
Ābeshkuh	F	U	Q	6
Bidestān	F	U	S	5
Pir Benow	F	U	Q	3
Padestān	F	U	S	4
Tavakolābād	D	L	Q	14
Chah Gow	F	U	S	1
Hojjatābād	D	L	Q	8
Hoseynābād	E	U	Q	7
Shah Morgh	E	L	Q	2
Shah Tut	E	U	Q	5
Abbāsābād	C	L	Q	7
Fakhrābād	D	L	Q	18
Gaz Darreh	F	U	S	6
Khanik	E	U	S	24
Golzār	F	U	S	9
Ahmadābād	E	L	W	10
Aliābād	E	L	Q-W	8
Kāzemābād	E	L	Q	11
Karimābād	D	L	Q	6
Valiābād	D	L	Q	6
Baghuru	F	U	-	3
Tak Shiru	F	U	-	1
Cheshmeh Teyhu	F	U	Q	7
Ṣar Puzeh	F	U	S	14
Lushu	F	U	S	7
Ma'dan-e-Ali Morād	D	U	Q	28
Yeylaq	F	U	Q	16

Appendix 8.1 Average cost, value and income per hectare of wheat, by major producing sub-zones (using actual farm cost and prices in 1970)

Area	COST							Total value per hectare	Total hect-arage income
	Ploughing	Seeds	Fertilizer	Water and irrigation	Harvesting	Invest	Total hectarage cost		
Mashhad	1,250	1,354	890	3,250	1,900	650	9,285	18,900	9,615
Quchen	1,080	1,345	940	2,140	1,540	800	7,845	15,750	7,905
Bojnurd	1,080	1,635	-	1,050	2,580	500	5,845	13,650	7,805
Neyshabur	1,130	1,597	920	4,330	1,830	800	10,517	18,900	8,383
Sabzavar	1,880	1,764	1,355	3,220	1,700	2,000	12,139	21,800	9,661
T.Haydar-iyeh	1,090	1,430	3,290	2,850	1,500	1,100	11,260	18,900	7,640
Kashmas	1,090	1,308	2,080	2,300	1,600	750	9,128	17,300	8,072
Birjand	1,030	1,320	2,720	2,600	1,400	500	9,570	16,800	7,230

Source : Plan organization, Agriculture and Livestock in Khorasan, 1972, p.13.

Appendix 8.2 Average cost, value and income per hectare of barley by major producing sub areas (using actual farm cost and prices in 1970)

Area	COST							Total value per hectare	Total hect-arage income
	Ploughing	Seeds	Fertilizer	Water and irrigation	Harvesting	Invest	Total hectarage cost		
Tabas	1,280	1,100	2,280	1,760	2,990	2,000	11,410	22,140	10,730
Kashmar	1,030	840	1,560	1,280	1,220	600	6,530	11,850	5,320
Shirvan	1,100	890	2,970	2,620	1,400	750	10,030	16,050	6,020
Dargaz	1,500	880	2,115	2,250	1,550	1,000	8,945	14,300	5,355
Birjand	1,030	800	2,055	2,080	1,400	500	7,865	13,155	5,290
Esfarayen	1,250	922	1,525	3,800	2,320	115	10,317	20,500	10,183

Source : Plan organization, Agriculture and Livestock in Khorasan, 1972, p.14.

Appendix 8.3 Average cost, value and income per hectare of sugar-beet, by major producing sub zones (using actual farm cost and prices in 1970)

Area	COST									Total volume per hectare	Total hectarage income
	Ploughing	Seeds	Fertilizer	Water and irrigation	Harrowing and weeding	Spraying poison	Harvesting	Invest	Total hectarage cost		
Mashhad	1,950	750	7,510	8,670	3,500	750	6,350	3,000	32,480	44,200	11,720
Shirvan	2,220	760	7,940	8,240	3,835	990	6,440	1,500	31,915	42,000	10,085
Bojnurd	2,220	750	9,400	6,800	4,480	900	9,260	1,500	35,310	38,400	3,090
Neyshabur	1,130	770	6,580	9,260	50,000	420	6,060	1,200	20,420	38,000	7,680
T.jam	1,500	900	4,140	8,600	3,260	1,800	6,000	1,300	27,500	31,380	3,880
T.Haydar-iyeh	1,450	680	6,420	8,800	2,880	1,050	5,320	2,000	28,605	33,800	5,195
Sabzavar	2,030	575	1,950	10,620	4,000	710	6,300	1,000	27,185	31,240	4,055
Birjand	1,230	680	4,030	420	2,000	460	4,415	1,000	21,730	26,100	4,365

Source as for Appendix 8.1

Appendix 8.4 Average cost, value and income per hectare of cotton, by major producing sub zones (using the actual farm cost and prices in 1970)

Area	COST									Total volume per hectare	Total hectarage income
	Ploughing	Seeds	Fertilizer	Water and irrigation	Harrowing and weeding	Spraying poison	Harvesting	Invest	Total hectarage cost		
Ferdows	2,100	500	5,920	7,940	3,260	1,155	3,260	1,500	25,635	37,400	11,765
Neysh-abur	1,130	385	7,280	7,260	6,000	514	2,250	1,200	25,019	30,600	5,580
Bojnurd	2,220	770	6,200	4,750	2,350	1,260	4,300	1,500	23,350	34,500	11,150
Gonabad	2,050	510	7,620	7,440	2,560	1,320	3,090	1,500	26,095	34.PPP	7.905
T. Haydar-iyeh	1,380	430	4,595	7,600	3,200	1,200	2,760	2,000	23,165	30,600	7,435
Kashmar	1,610	570	3,995	6,880	4,040	1,385	2,910	2,500	23,890	30,600	6,710
Esfarayen	1,350	850	4,075	8,800	4,000	1,320	1,900	1,000	23,295	34,000	10,705
T.jam	1,500	720	7,780	7,740	3,360	1,360	3,232	1,500	27,190	42,500	15,310
Dargaz	2,100	455	7,530	7,600	4,200	1,205	3,590	2,000	28,680	35,700	7,020
Sabzavar	2,180	520	5,260	7,620	2,100	840	2,000	6,000	26,520	36,700	9,160

Source as for Appendix 8.1

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